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BULLETIN No. 173

NORTH COASTAL AREA INVESTIGATION

SOUTH FORK EEL RIVER STUDY

Preliminary Edition

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JANUARY 1968

RONALD REAGAN
Governor
State of California

WILLIAM R. GIANELLI
Director
Department of Water Resources

State of California

THE RESOURCES AGENCY

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FOREWORD

This report presents the results of a two-year reconnaissance investigation of the South Fork Eel River Basin.

The objective of this study was to analyze possible water development projects in the basin which might be constructed for local water supply, flood control, recreation, and fisheries enhancement. The Department of Water Resources initiated this study under the provisions of Sections 12616 to 12634 of the Water Code, on the basis of recommendations in Bulletin No. 92, "Branscomb Project Investigation", February 1965, and the comments received at the public hearing on that bulletin.

Included in the South Fork Eel River Study were preliminary examinations of all known dam and reservoir sites in the basin and more detailed evaluations of the several more favorable of these sites. As a result of the investigation it was concluded that two developments, Cahto Reservoir Project on Tenmile Creek and Panther Reservoir Project on the East Branch of the South Fork, are economically justified. The Cahto Project would be an excellent multipurpose development, oriented primarily toward recreation. The Panther Project would be primarily for water conservation and would be economically justified only if a demand develops within the study area for the conserved water. The Cahto Project should be given primary consideration as the initial development within the South Fork Eel River Basin.

William R. Gianelli

William R. Gianelli, Director
Department of Water Resources
The Resources Agency
State of California
November 17, 1967

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The Resources Agency

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ABSTRACT

The South Fork Eel River was the first basin to be surveyed under the local project phase of the continuing North Coastal Area Investigation of the Department of Water Resources./ Largely because of Highway 101 and the redwood parks, the basin has more local population than other interior basins in the North Coastal area north of the Russian River. The relatively accessible scenic area attracts a tremendous summer visitor population. The area needs flood control, future municipal and suburban water supplies, increased summer streamflows for recreation and fisheries enhancement, and reservoir recreation opportunities. Furthermore, because of its geographic location, the South Fork Eel River Basin cannot logically be supplied with water by any proposed major North Coastal developments./ The water resources of the basin are almost completely undeveloped. Runoff from the basin, amounting to about 1.5 million acre-feet per year, occurs principally in the winter. Streamflows in the summer and early fall, when water requirements are highest, are at present barely adequate to meet the existing needs./ Major flood control works on the main stem of the South Fork Eel River are impractical due to excessive costs and the potential adverse effect on anadromous fish. The most practical measure to prevent flood damage would be a comprehensive program of floodplain management./ Of the projects evaluated, two were found to merit consideration for future development, the Cahto Project on Tenmile Creek and the Panther Project on the East Branch of the South Fork Eel River./ Appendixes include project evaluation reports by the Department of Parks and Recreation and the Department of Fish and Game.

Acknowledgment

Many organizations and individuals contributed valuable assistance to the South Fork Eel River Study. Cooperation and assistance received from the following is gratefully acknowledged.

Corps of Engineers, United States Army
California State Department of Fish and Game
California State Department of Parks and Recreation
California State Department of Public Works, Division of Highways
Rockport Redwood Company
Mr. Otto C. von Seggern, P.E.
Residents of the South Fork Eel River Basin, including Mr. Clyde Baleme, Mr. B. W. Benbow, Mrs. Adah Blinn, Mr. Bill Brown, Mr. John Ek, Mr. E. P. French, Mr. E. M. Nelson, Mr. Chip Nunnamaker, Mrs. Laura Pulscher, Mr. Lewis E. Spengler, and Mr. Harold E. Tucker.

CHAPTER 1. SUMMARY

The development of new water supplies in the North Coastal area is recognized as one of the keys to sustaining California's dynamic growth. Over the past 20 years the Department of Water Resources and predecessor agencies have been formulating a planning framework to assure that each new project in this area represents a logical and orderly increment in long-range development. The initial phases of the Department's North Coastal studies were centered on major projects to conserve the surplus waters of the area. Following the publication of Bulletin No. 136, "North Coastal Area Investigation", in 1964, continuing studies of the North Coastal area were divided into two main parts: (1) major project studies to plan large conservation developments and (2) local project studies to identify possible projects to supply the needs of areas that could not be served by the proposed major developments. The South Fork Eel River was the first basin to be surveyed under the local project phase of the continuing North Coastal Area Investigation.

Background

The South Fork Eel River Basin was selected as the first area to be surveyed for local projects for several reasons. Largely because of Highway 101 and the redwood parks, the basin has more local population than other interior basins in the North Coastal area north of the Russian River. The relatively accessible scenic area attracts a tremendous summer visitor population. The area needs flood control, future municipal and industrial water supplies, increased summer streamflows for recreation and fisheries ennancement, and reservoir recreation opportunities. Furthermore, because of its location, the South Fork Eel River Basin cannot logically be supplied with water by any proposed major North Coastal developments.

The Department had previously investigated the Branscomb Project, a development on the headwaters of the South Fork first pointed out in Bulletin No. 3, "The California Water Plan". The final report on that

investigation recommended that this project not be authorized until studies of alternative projects on a basin-wide development concept for the South Fork Eel River Basin were completed.

In accordance with a legislative resolution, the Department in 1964 made a preliminary examination of a possible dam and reservoir project, called Lower Lake Benbow, on the South Fork near Garberville. Primarily because of its possible damage to migrating fish, the Department did not recommend further action on that project, but recommended a basin-wide study of alternatives. Thus, the South Fork Eel River Study was a logical step following both the first phase of the North Coastal Area Investigation and the Branscomb Project Investigation.

The South Fork Eel River Study relied heavily on previous departmental studies of the Eel River Basin. The principal sources of information were:

1. Bulletin No. 92, "Branscomb Project Investigation", February 1965. This study of the proposed Branscomb Dam and Reservoir on the upper South Fork was inconclusive due to the lack of determination of fisheries benefits and detriments. The report provided a valuable reference for problem areas, specifically on fisheries. The recommendation in Bulletin No. 92 for a basin-wide investigation of the South Fork Eel River led to the initiation of the South Fork Eel River Study in July 1965.

2. Bulletin No. 94-8, "Land and Water Use in the Eel River Hydrographic Unit", August 1965. This report presents detailed basic data regarding land and water use and apparent water rights in the Eel River Basin. The hydrographic unit and subunit boundaries delineated in Bulletin No. 94-8 were used to subdivide the South Fork Basin study area as shown in Figure 1.

3. Appendix A, "Watershed Management in the Eel River Basin", to Bulletin No. 136, "North Coastal Area Investigation", September 1966. This appendix deals with current and historical watershed management problems of the Eel River Basin, the responsibilities of state and federal agencies with respect to watershed management, and the watershed management needs in the Eel River Basin.

4. Bulletin No. 142-1, "Water Resources and Future Water Requirements, North Coastal Hydrographic Area", April 1965. This basic data report presents detailed information on the water resources and future water requirements of a portion of the North Coastal area, including the Eel River Basin.

5. Bulletin No. 160-66, "Implementation of the California Water Plan", March 1966. This report contains current estimates of growth in population and water requirements for California and the sizing and timing of future water projects which now appear to be needed by the year 2020. Together with Bulletin No. 142-1, it provided the basis for estimating future water requirements of the South Fork Basin study area.

In addition to the above reports, the South Fork Eel study was influenced by a report prepared by a consulting engineer, Mr. Otto C. von Seggern, and presented at the public hearing on Bulletin No. 92. His report, entitled "Preliminary Planning Report on Plans for South Fork Eel River Multipurpose Project as an Alternative to the Branscomb Bulletin No. 92 Site Plans", proposed the construction of reservoir developments on main tributaries to the South Fork Eel River, to provide streamflow regulations, water conservation, and water surface for recreation. The report also included a proposal for low-level check dams to create recreation pools at selected sites along the South Fork Eel River. These would be constructed as needed near state parks and local communities. The South Fork Eel River Study closely paralleled the ideas and objectives presented in Mr. von Seggern's report.

The above reports and other references used in preparing this report are listed in Appendix A, Bibliography.

Objectives and Scope

The objective of the South Fork Eel River Study was to identify possible local projects in the basin which might be constructed for local water supply, flood control, recreation, and fisheries enhancement. Economically justified projects which would merit more detailed studies were to be selected and appropriate recommendations made regarding the additional studies needed.

Preliminary examinations were made of all known dam and reservoir sites in the basin with respect to water supply yields, geologic conditions, recreation values, and fish and wildlife enhancement values. The several more favorable of these project sites were examined in more detail, including flood control evaluations. Three projects showed sufficient potential to warrant reconnaissance-level analysis of engineering feasibility and economic justification.

A limited study was also made of low dams on the main stem of the South Fork Eel River for recreation.

Conclusions

The South Fork Eel River Basin is rich in natural resources, including water, timber, fish and wildlife, and magnificent redwood forests. The orderly and timely development of these resources is essential to the future economic growth of the basin.

The water resources of the basin are almost completely undeveloped. Runoff from the basin, about 1.5 million acre-feet per year, occurs principally in the winter. Streamflows in the summer and early fall, when water requirements are highest, are barely adequate to meet the existing needs. The basin needs water development projects to conserve the winter runoff, to provide flood control, to provide additional water in the summer for urban and irrigation use, and to enhance recreation and fishery potential.

The South Fork Basin is susceptible to damage by flooding and will probably remain so for some time. The flood control potential of developments on the tributary streams is very limited due to the small percentage of the total surface runoff that could be controlled. Major flood control works on the main stem of the South Fork Eel River are impractical due to excessive costs and the potential adverse effect on anadromous fish. The most practical measure to prevent flood damage would be a comprehensive program of floodplain management. Some lands within the floodplain would be ideally suited for recreational use.

Low-level temporary dam structures have been used at various locations in the basin for many years. These structures appear to have

an excellent potential for recreational development. The Department of Parks and Recreation believes that such structures should occupy an important position in future planning in the basin. Studies of low-level dams would logically be initiated by any local community directly affected by a proposed project.

There will be a large increase in water requirements in the study area in the future; the combined requirement of the South Fork Basin and the Lower Eel subunit will increase from the present level of 30,000 acre-feet per year to an estimated 71,000 acre-feet by the year 2020 and to about 94,000 acre-feet by the year 2070. The population of the basin will increase from 10,500 (1960) to about 59,000 by the year 2070.

Project Analyses

Of the 24 potential damsites surveyed, only three were selected for detailed economic analysis. The remaining sites were dropped from the study for various reasons, primarily unsound geologic conditions and lack of potential for recreation development. As a result of the economic analysis of these three projects, the following conclusions were reached:

1. The Cahto Project on Tenmile Creek, with a reservoir storage of 95,500 acre-feet, could provide 20,000 acre-feet of flood control storage; a firm yield of 18,000 acre-feet per year for urban, recreation, and agricultural use; an increase of about 3,200 king and silver salmon in the commercial catch and 1,100 salmon and steelhead in the sport catch; and would ultimately provide for about 3,750,000 visitor-days per year of water-associated recreation use. The project is economically justified, with a ratio of benefits to costs of 2.11 to 1.00. Construction of this project in coordination with the planned improvement of Highway 101, currently scheduled for about 1975, could result in substantial economies.

2. The Panther Project on the East Branch of the South Fork Eel River, with a reservoir storage of 80,200 acre-feet, would provide a firm annual yield of 63,000 acre-feet for industrial, urban, recreation, and irrigation use; an increase of about 5,000 king and silver salmon in the commercial catch, and 1,800 salmon and steelhead and 17,500 trout in the sport fishery;

and environment for up to 56,000 visitor-days per year of water-associated recreation. The project is economically justified and has a benefit-cost ratio of 1.14 to 1.00.

3. The Standley Project on the upper South Fork Eel River, with a reservoir storage of 16,500 acre-feet, would provide a firm yield of 2,500 acre-feet per year for urban and recreation use; an increase of about 1,300 silver salmon in the commercial catch, and 550 salmon and steelhead and 9,000 trout in the sport fishery; and environment for up to 60,000 visitor-days per year of water-associated recreation. The project is not economically justified under present conditions, since the ratio of benefits to cost is 0.76 to 1.00.

Basin Development

Initial development of the water resources of the South Fork Eel River Basin could best be accomplished by the construction of the Cahto Project on Tenmile Creek. This project could meet the growing water needs of the basin and the Lower Eel subunit until about 1990 and would provide an outstanding recreation attraction in the Laytonville area. Construction of the Cahto Project could defer the need for the Panther Project until 1990 or until the water needs of the area increase substantially.

The Cahto Project would provide an excellent opportunity for joint participation by state, federal, and local agencies in the coordinated development of the basin's water resources. It is also compatible with state and federal plans for coordinated development of the entire Eel River Basin.

Recommendations

It is recommended that:

1. This bulletin be used as a guide in the development of the water resources of the South Fork Eel River Basin, and the plans presented herein be reviewed periodically to reflect changing needs within the area.

2. The Cahto Project on Tenmile Creek be given primary consideration as the initial development within the South Fork Basin.

3. Interested agencies explore possible methods of authorizing and financing the Cahto and Panther Projects and then take action to initiate a feasibility-level study of one or both of these projects.

4. Efforts be made to coordinate the construction of the Cahto Project with the planned improvement of Highway 101 in the project area.

5. Humboldt and Mendocino Counties initiate zoning ordinances or other legal measures to preserve the sites of the Cahto and Panther Projects for future use.

6. The Cahto and Panther Projects be adopted as part of a coordinated plan of development for the Eel River Basin by the California State-Federal Interagency Group.

7. Humboldt and Mendocino Counties adopt a comprehensive program of floodplain management or zoning as the best method of preventing major damage by floods in the South Fork Eel River Basin. The counties should explore the possibilities of land exchanges with state or federal agencies to relocate communities from the floodplain.

8. Interested communities on the South Fork Eel River explore the potential development of temporary low-level dams for recreational purposes.

CHAPTER 2. THE SOUTH FORK EEL RIVER BASIN

Although the rugged South Fork Eel River canyon, traversed by the world-famous Redwood Highway, is better known than any other portion of the Eel River Basin, most travelers visit only the highway corridor and adjacent communities and redwood parks. Most of the South Fork country is as little known as the more remote parts of the North Coastal area.

The South Fork Eel River, with a drainage area of 690 square miles, is the second largest tributary to the Eel River, after the Middle Fork. Its drainage basin is approximately 60 miles long and 12 miles wide. The Humboldt-Mendocino County line divides the basin roughly in half.

The study area for this investigation includes the 690 square miles of the South Fork Basin and 214 square miles of the lower Eel River Basin. The area comprises four subunits of the Eel River hydrographic unit, as designated in Bulletin No. 94-8. These four subunits, Laytonville, Lake Benbow, Humboldt Redwoods, and Lower Eel, provide the basis for subdivision of population and water requirement estimates. Figure 1 shows the location and subunit division of the study area. The following sections describe the physical characteristics, economic development, water supply, and water requirements of the South Fork Basin.

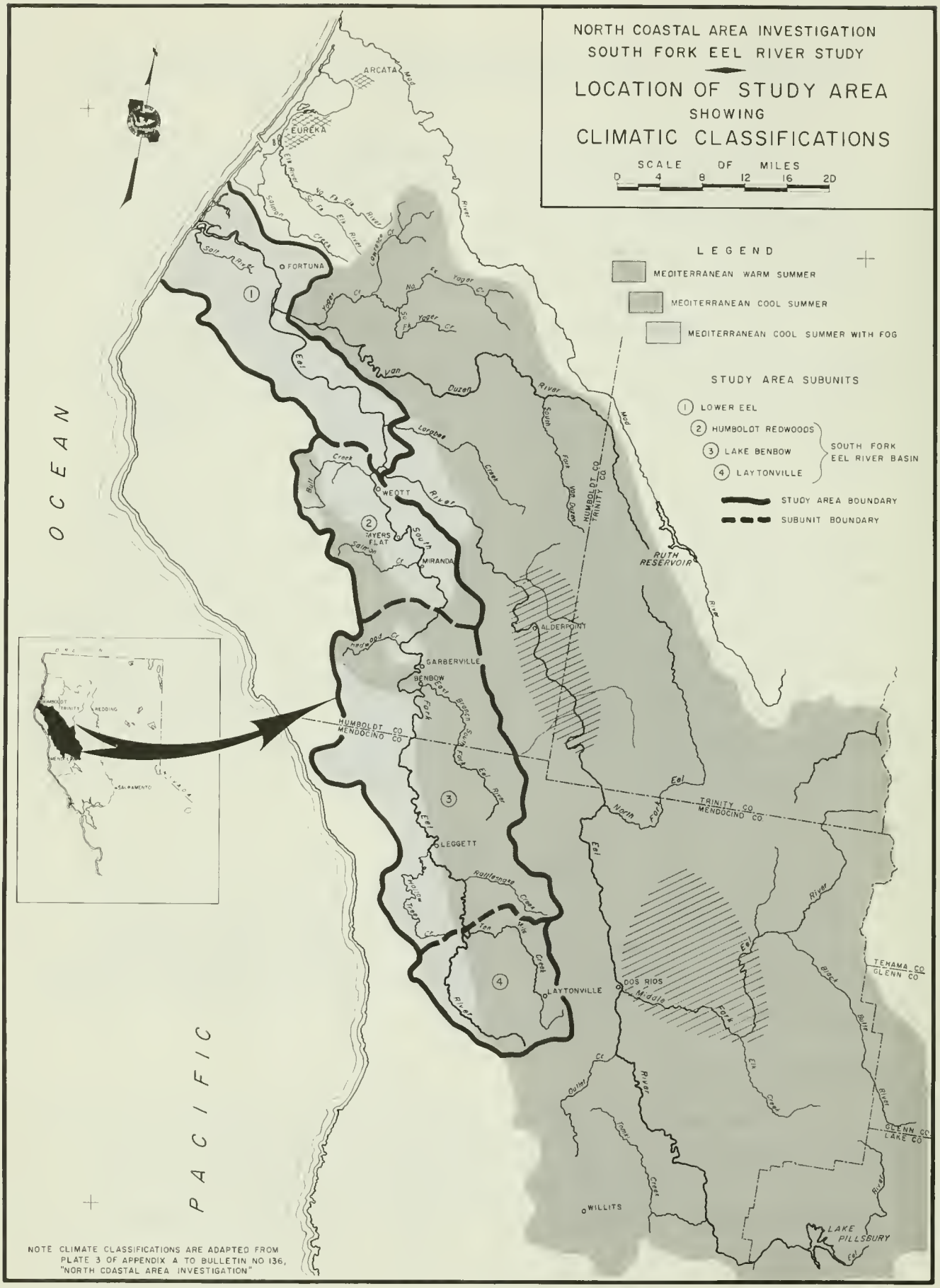
Physical Description

No extensive part of the study area is homogeneous with respect to geology, soils, climate, or vegetation. Vegetation varies according to elevational and climatic zones, all the way from dense redwoods through mixed conifers and brush to grasslands.

Topography and Geology

Like the North Coastal area in general, the South Fork Eel River Basin is mountainous and rugged. Elevations range from about 100 feet near Weott to 4,491 feet at Iron Peak northeast of Laytonville. Less than four percent of the land in the basin is classified as irrigable.

FIGURE 1



NOTE CLIMATE CLASSIFICATIONS ARE ADAPTED FROM PLATE 3 OF APPENDIX A TO BULLETIN NO 136, "NORTH COASTAL AREA INVESTIGATION"

The only sizable valley in the basin is Laytonville Valley, in the southernmost end of the basin, along Tenmile Creek. The valley has an area of about 12 square miles - 9 miles long in a northwesterly direction and up to 2.2 miles wide. Most of the irrigable land in the basin is in Laytonville Valley, with the remainder scattered throughout the basin in a number of much smaller valleys and old stream terraces. The towns in the basin are located mainly on such terraces along Highway 101, including Garberville, Leggett, Miranda, Myers Flat, and Weott.

The basin lies in the Coast Range geomorphic province. The province is characterized by elongated northwest-trending ridges and valleys which are controlled largely by the underlying geologic structures, including faults and folds.

Landsliding is widespread throughout most of the Coast Range slopes. The highly fractured and sheared nature of the bedrock combined with deep chemical weathering results in unusually thick layers of unstable soils. Commonly, the material slowly moves downslope as an earthflow type of landslide during and after long periods of intense rainfall.

Climate

The climate of the South Fork Eel River Basin is characterized by heavy annual precipitation, concentrated in the winter months. The portions nearest the coast are subject to frequent sea fog, mostly in the summer. Polar air masses sweeping south from the Gulf of Alaska create the storm fronts responsible for most of the winter storms. Occasionaly, much warmer storms originating farther south in the Pacific Ocean invade the North Coastal area and release very heavy precipitation. Two such storms in December 1955 and December 1964 caused the highest floods of record.

The climate of the South Fork Basin, with its characteristic heavy winter rainfall and hot, dry summers, has been described as Mediterranean with subregional variations. The climatic classifications described in the following sections, and shown on Figure 1, are based on a 1959 office report by the Department, "Classification of Climate in California".

Mediterranean Cool Summer With Fog. This is the well known "fog belt" in which the famous coast redwoods are found. Moderate and uniform temperatures prevail here. Average annual temperatures vary between 50 and 55 degrees Fahrenheit; average summer temperatures are less than 72 degrees Fahrenheit. Snow seldom occurs in this zone.

Two notable variations in this general class of climate occur. The first is the "temperate rainforest" or "monsoon" type, where sufficient moisture is maintained during the summer to support a "rainforest" type of vegetation. The normal rainfall is added to by a phenomenon known as "fog drip", wherein fog particles condense on vegetation and drop to the ground, adding to the total precipitation. The second is the light fog belt, which establishes the range of coast redwood up the river valleys, but out of the fog belt proper. Typically, this fog occurs in lower elevations on summer mornings, and is strongly influenced by northwestern winds. It is dissipated by sunshine as the day progresses and is usually completely gone by noon. The area shown on Figure 1 delineating these variations is synonymous with the interior range of the coast redwood.

Mediterranean Cool Summer Without Fog. This zone lies directly east of the fog belt and covers the balance of the South Fork Eel River drainage area. Because of the orographic effect of topography, precipitation varies from about 40 to 80 inches. Although most of this zone receives some snow, it accumulates only at the higher elevations in the eastern part of the basin. Summers in this zone are usually moderately warm and dry.

Mediterranean Warm Summer. This climate pattern occurs in some of the more inland mountain valleys, and in an area around Alderpoint. It is similar to that of the Sacramento and San Joaquin Valleys, but with more winter precipitation. This classification is not found within the South Fork Basin, although the area around Laytonville approaches the borderline between this and the preceding classification.

Stream System

The long, narrow South Fork Eel River Basin is drained by one principal stream with a large number of small tributaries. The East Branch of the South Fork (Table 1) is the largest of the tributaries from the

standpoint of drainage area. Its 76 square miles comprise 11 percent of the basin. From the standpoint of runoff, the East Branch is rivaled by Bull Creek and Salmon Creek. These latter two streams contribute a disproportionate amount to the runoff of the basin due to the greater rainfall on their drainages. Runoff quantities will be discussed in detail in a later section of this chapter.

TABLE 1

DRAINAGE AREAS OF TRIBUTARIES
TO THE SOUTH FORK EEL RIVER

Stream	Drainage Area in Square Miles
East Branch of South Fork	76.0
Tenmile Creek	65.5
Bull Creek	42.2
Hollow Tree Creek	41.6
Rattlesnake Creek	38.2
Salmon Creek	36.8
Indian Creek	26.9
Redwood Creek	26.0
Sprowl Creek	23.9
Others	312.7
Total South Fork Basin	689.8

Development

Before the white man came into the area, the Kato, or Kaipomo Indians occupied the larger valleys on the headwaters of the South Fork, known today as the Laytonville, Branscomb, and Cahto Valleys. The Indians in the lower part of the basin were known as the Sinkyone, after their name for the South Fork, Sinkyoko. The first white settlers came in the 1850's. By 1855, logging had already taken its place as the leading industry in the North Coastal area. The first auto traffic into the basin started about 1911, and today the Redwood Highway is one of the most heavily used in the State.

Population

The total population in the South Fork Basin in 1960 was about 10,500. The largest community in the basin is Garberville, with a population of 1,350. Other communities in the basin include Redway (1,100), Laytonville (897), Weott (450), and Leggett (430). About two-thirds of the study area population (Figure 2) is centered in the Lower Eel subunit, where most of the level usable lands are located.

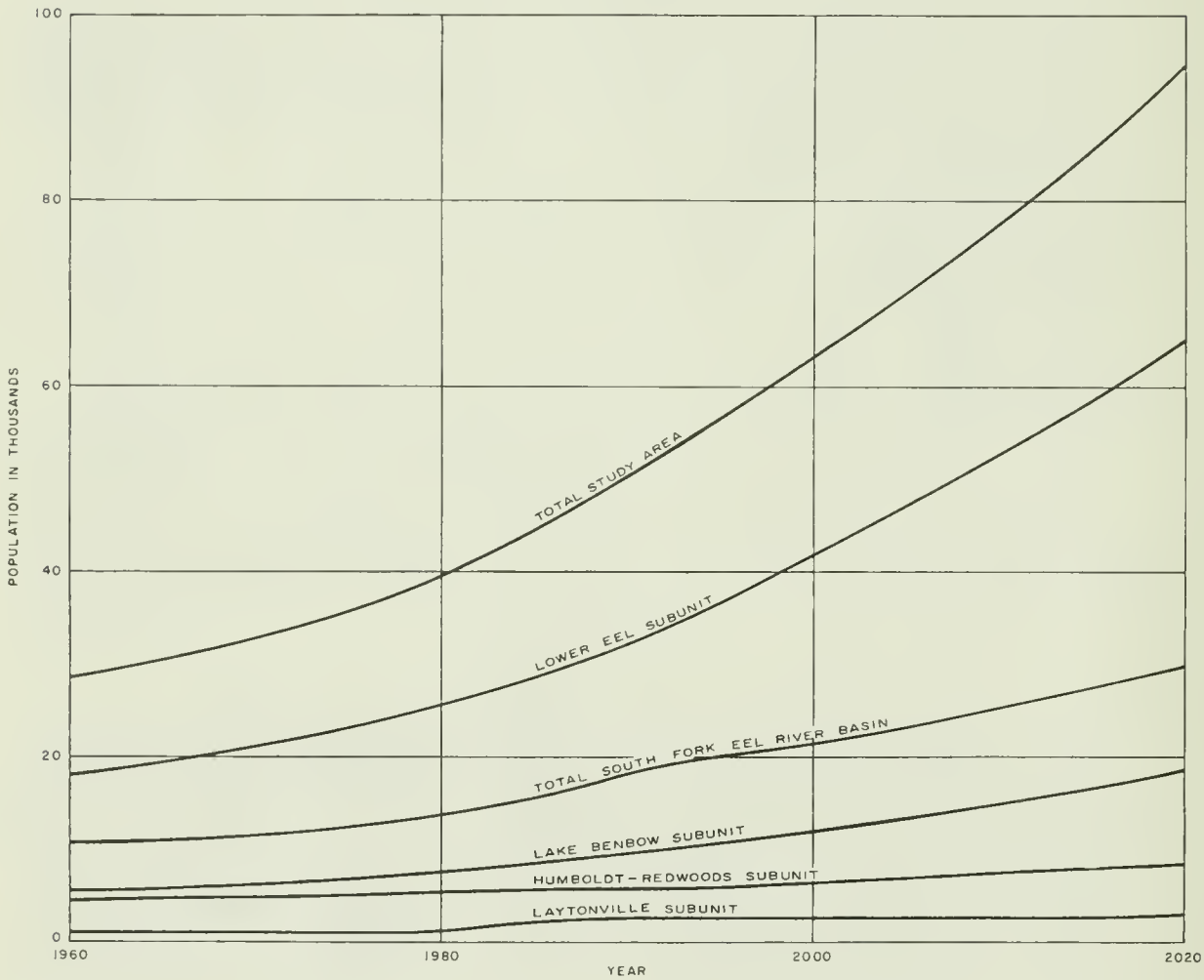


Figure 2. PROJECTED STUDY AREA POPULATION

The total attendance at the two principal redwood state parks in the basin, Humboldt Redwoods and Richardson Grove, in 1964-65 was 953,700 visitors. This figure when compared with the resident populations indicates the tremendous impact of tourism on the economy of the basin.

Transportation

For many years development in the region was inhibited by the difficulty of constructing a transportation system in the rugged terrain. In his diary, Jedediah Smith, one of the first explorers of the area, refers to a horseback pace of two to four miles per day through the steep-ridged and heavy-timbered country. The susceptibility of the land to sliding was not the least of the difficulties and to this day makes the maintenance of highways in the area costly.

The original wagon road to the North Coast went up Mail Ridge on the east side of the basin, where a little-used county road is still located. The completion of the major highway along the South Fork Eel River (now Highway 101) in 1918 brought the first surge of tourists to the redwood groves along the river and provided access for sportsmen in search of salmon and steelhead fishing in North Coastal streams.

State Highway 208, from Leggett, links Highway 101 with Fort Bragg and the Mendocino Coast. The state-maintained Avenue of the Giants, paralleling Highway 101 for about 20 miles in the lower north end of the basin, is well known to redwood park visitors. East-west county roads traverse the basin near Laytonville, Redway, and Weott.

The Northwestern Pacific Railroad, a major addition to the transportation system in the area, was completed in 1915. This rail line is just outside the South Fork Basin in the canyon of the main Eel River. Much of the lumber produced in the basin is shipped on this railroad.

Lumber Industry

As is true for the whole North Coastal area, the lumber industry developed soon after initial settlement of the basin. It quickly became, and still is, the most important segment of the economy. The industry, concentrated in the redwood belt, uses both redwood and Douglas fir timber and employs about 40 percent of the workers in the area. At present,

timber cutting in the area is exceeding growth by about two and one half to three times, as virgin (or overmature) stands are still being harvested. This situation is likely to persist for another 15 to 20 years, after which cutting is expected to continue on a sustained yield basis. Even when this sustained yield operation has been reached, the industry will continue to have a major influence on the basin economy.

Pulp and paper production, which has historically tended to follow in the wake of a well established lumber industry, has already arrived in the North Coastal area. Two large pulp mills are in production in the vicinity of Eureka, and at least one more mill is expected in the Lower Eel River area before 1990. This diversification will tend to stablize the industry as a permanent feature of the economy of the basin.

The advent of a pulp and paper industry, together with an increase in the demand for veneer and plywood, will result in more intensive use of forest lands. Thus, for the timber-oriented segment of the basin economy, increasing demands will create a trend toward maximum use of the forests of the basin.

Recreation

Recreation plays a major role in the economy of the area, ranking second only to lumbering. The majestic redwoods, steelhead and salmon fishing, and deer hunting are some of the major attractions. During 1965 there were over a million visitor-days of use in the redwood parks in the basin. As important as recreation is now, the potential is just beginning to be developed.

Several related factors are working in concert to emphasize the economic importance of the recreation industry. First, a major transformation in the economic structure will result from the use of the reserve of standing timber. Recreation activities will assume a more dominant position in the economic base of the area as the lumber industry changes to a sustained yield operation and a lower but more stable level of employment. Second, the relative remoteness of the area will diminish as Highway 101 is improved to freeway standards. Third, reservoir development in the South Fork Eel River Basin, such as the Cahto Project described in Chapter 4 of this report, would provide increased opportunities for prolonged recreation pursuits in the redwood country.

The redwood parks are a major economic asset of the South Fork Eel River Basin. The largest segment of present recreational activities occurs in the parks, although the economic impact is focused in the larger communities where services are available. Records at Richardson Grove State Park (Appendix B) indicate that over 50 percent of the camp use is for only a one-day stay. Park administrators estimate that approximately 80 percent of the reported visitation in the redwood parks represents sight-seeing.

It has been estimated that 60 percent of all recreation use in California is water-associated. Yet there is at present no effective reservoir development to complement the esthetic recreation potential of the South Fork Eel River Basin except the Benbow Lake State Recreation area. This 123-acre lake, which now accommodates an average use of about 43,000 visitor-days per year, has a safety restriction that allows not more than 15 boats in operation at one time. The Department of Parks and Recreation has estimated that Benbow Lake can be developed to accommodate up to 121,600 visitor-days per year, compared to a recreation demand that is estimated at 2,438,000 visitor-days by 2020 and 5,850,000 visitor-days by 2070. It is apparent that Benbow Lake alone is inadequate to satisfy the growing demand for varied recreational opportunities, particularly boating.

The development of water-associated recreation sites in the basin, offering a variety of pursuits such as boating, swimming, water-skiing, and fishing, would induce recreationists to lengthen their stay in the redwood country. This would benefit both the recreationist and the local economy.

Agriculture

The third industry in importance in the South Fork Eel River Basin is agriculture, largely centering around livestock and rangeland grazing. Because of the limited extent of irrigable land and the distance to market, only about 800 acres are presently irrigated. Nearly all of this acreage is in irrigated pasture and about half is located in Laytonville Valley. The projected irrigated acreage in 1990 is 2800 acres, still largely irrigated pasture in Laytonville Valley.

In the adjacent Lower Eel hydrographic subunit, which could be served a firm water supply from reservoirs on the South Fork, irrigated

Natural pools and beaches on the river attract recreationists

Near Weott

Near Miranda

At Garberville

LAKE BENBOW STATE RECREATION AREA

Department of Water Resources Photographs

agriculture is a very significant industry. Irrigated pasture for dairying is the principal land use, with about 13,000 acres at present and over 22,000 acres projected in 1990.

Table 2 shows the projected land use within the study area. The data for the period 1960-2020 were derived from Department of Water Resources Bulletins No. 94-8 and No. 142-1. Data for the period 2020-2070 are estimates made by projection of the trends in land use during the period 1960-2020. These data were used in deriving the urban and irrigation water requirements for the study area.

Irrigated agriculture faces the competition of urban development for the limited irrigable lands in the basin. Urban encroachment will completely displace agriculture in the Lake Benbow and Humboldt Redwoods subunits by the year 2020. In the Lower Eel and Laytonville subunits, with the much greater extent of irrigable lands, agriculture is expected to increase until about 2020 and hold steady or decline slightly beyond that time.

TABLE 2

PRESENT AND PROJECTED LAND USE
IN THE
SOUTH FORK EEL RIVER STUDY AREA
(in acres)

	LAYTONVILLE SUBUNIT		LAKE BENBOW SUBUNIT		HUMBOLDT REDWOODS SUBUNIT		LOWER EEL SUBUNIT		TOTAL	
YEAR	Urban	Irrigated Agriculture	Urban	Irrigated Agriculture	Urban	Irrigated Agriculture	Urban	Irrigated Agriculture	Urban	Irrigated Agriculture
1960	400	170	1900	180	1700	90	6400	11290	10400	11730
1970	400	400	2100	300	1800	100	7200	14500	11500	15300
1980	440	1000	2400	600	2000	200	8200	18500	13040	20300
1990	830[1/]	1600	2800	900	2200	300	9500	22500	15330	25300
2000	830	2200	3300	600	2400	200	11300	24500	17830	27500
2010	870	2800	3800	300	2600	100	12800	24500	20070	27700
2020	900	3500	4400	0	2800	0	14300	23100	22400	26600

1/ The significant increase over 1980 reflects an expected population increase due to construction of major water projects in the upper Eel River Basin.

Water Supply

Present and predicted future water requirements in the basin are almost insignificant in comparison with the magnitude of the water supply originating in the basin. Storage is needed, however, to even out this supply over the year -- to protect against damaging flood flows in the winter and to supplement inadequate flows in the summer.

With no significant storage in the basin, the runoff pattern is directly responsive to rainfall, after initial soil saturation. The only significant reservoir in the basin is Lake Benbow with 1,060 acre-feet of storage, now used entirely for recreation.

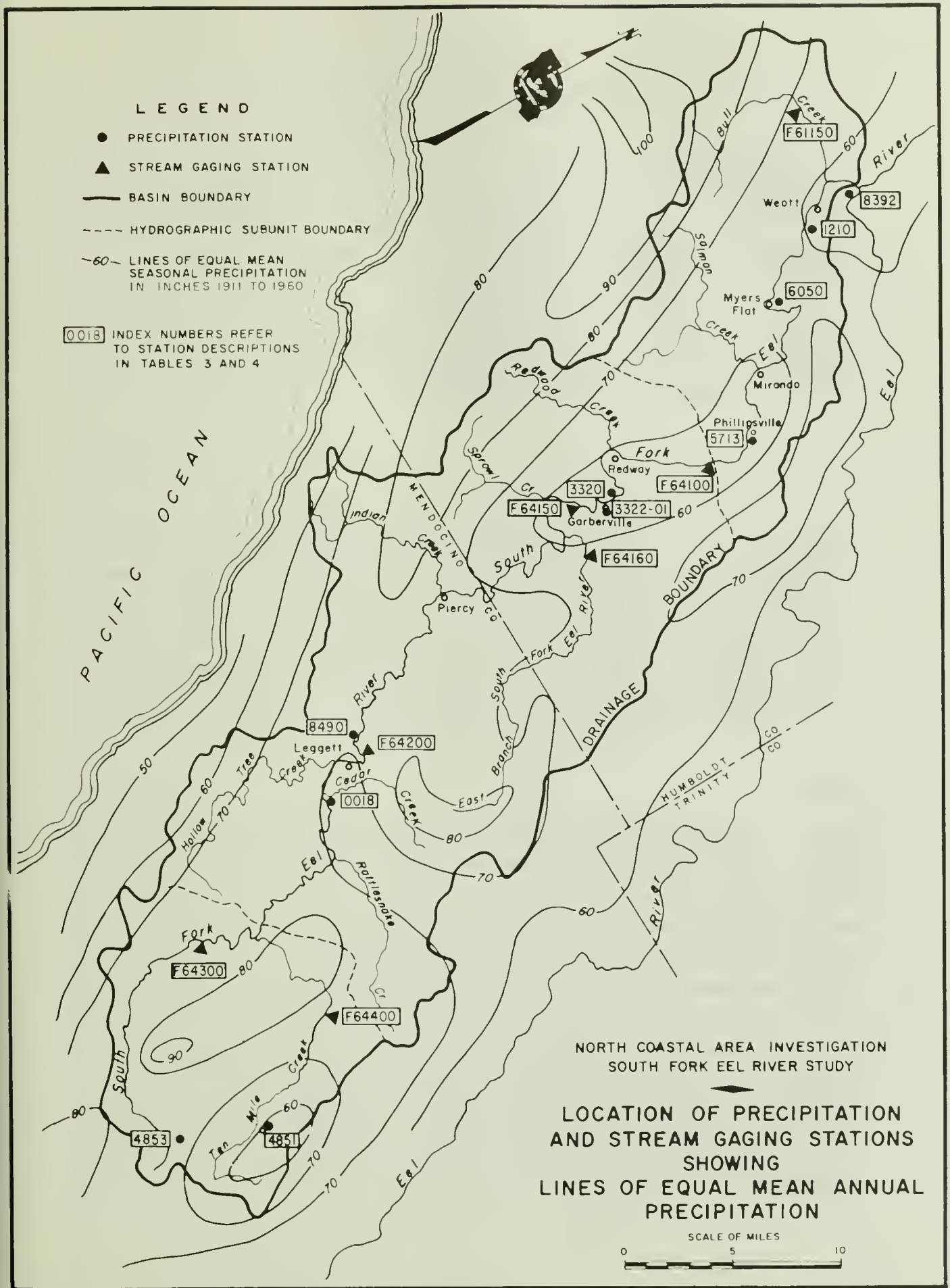
Precipitation

Precipitation in the basin averages about 71 inches annually, varying geographically from about 60 inches in the interior valleys and canyons to about 100 inches on the seaward ridge at the northern end of the basin. The annual variation is much greater; for example, the recorded annual rainfall at Laytonville (1917-1958) ranges from 34 to 135 inches. Figure 3 shows an isohyetal map for the basin, including the locations of precipitation and stream gaging stations listed in Tables 3 and 4.

TABLE 3

PRECIPITATION STATIONS WITHIN THE
SOUTH FORK EEL RIVER BASIN

DWR Ref. No.	Name of Station	Period of Record
0018	Adanac Lodge	1950-
1210	Burlington State Park	1950-
3320	Garberville	1947-
3322-01	Garberville Maintenance Station	1935-
4851	Laytonville	1940-
4853	Laytonville, 3SW	1917-1958
5713	Miranda, Spengler Ranch	1939-
6050	Myers Flat	1950-
8392	South Fork	1944-1960
8490	Standish Hickey Park	1950-



NORTH COASTAL AREA INVESTIGATION
SOUTH FORK EEL RIVER STUDY

LOCATION OF PRECIPITATION AND STREAM GAGING STATIONS SHOWING LINES OF EQUAL MEAN ANNUAL PRECIPITATION

SCALE OF MILES
0 5 10

TABLE 4

STREAM GAGING STATIONS WITHIN THE
SOUTH FORK EEL RIVER BASIN

DWR Index No.	Name of Station	Period of Record
F 61150	Bull Creek near Weott	1960-
F 64100	S. F. Eel River near Miranda	1939-
F 64150	S. F. Eel River at Garberville	1911-1913, 1939-1940
F 64160	E. Br. S. F. Eel River near Garberville	1966-
F 64200	S. F. Eel River near Leggett	1964-
F 64300	S. F. Eel River near Branscomb	1946-
F 64400	Tenmile Creek near Laytonville	1957-

Most of the precipitation is in the form of low-intensity winter and spring rain. Although snowfall is common along the higher ridges, it rarely accumulates sufficiently to have any significant effect in delaying the runoff. Typically the seasonal rains begin in late September or October, reach a maximum from December to February, and cease in late May or early June. About 95 percent of the annual precipitation occurs in the eight-month period October through May and about 80 percent in the six-month period November through April.

Runoff

Because of the relative lack of snow and natural storage, streamflow is highly responsive to rainfall. The runoff pattern is directly related to precipitation in time and quantity. The relationship of precipitation and runoff is graphically illustrated by the record of the gaging station near Miranda for the 1964-65 water year. On December 22, 1964, five days of extremely heavy rainfall generated a flow of 199,000 cubic feet per second (cfs) at this point, raising the water level about 46 feet and causing widespread destruction in the lower reaches of the South Fork. The average daily flow dropped to 17,500 cfs by December 27 and did not exceed this amount through the remainder of the winter and spring. The average daily flow throughout the period from June 1 to September 30, 1965, did not exceed 300 cfs.

Hydrologic studies for this investigation reevaluated the surface runoff within the South Fork Eel River Basin in light of additional streamflow data collected in recent years. Table 5 presents a summary of the mean seasonal runoff in the basin, starting at locations in the upper basin and proceeding downstream in incremental areas to the mouth of the South Fork. The monthly distribution of average annual runoff is presented in Table 6. Tables 7 through 11 present estimates of monthly and seasonal runoff that were derived for the major gaging stations and damsites under study. Streamflow at the proposed Cahto Dam was not tabulated because the gage, "Tenmile Creek near Laytonville", is very near the damsite. Flows at the gage were taken as equivalent to the runoff at the damsite.

Water Quality

Surface waters in the South Fork Basin are generally characterized as a soft calcium-sodium-bicarbonate type with low concentrations of boron and of suitable quality for all anticipated uses. The Laytonville Valley area has at least one highly mineralized spring (Pinches Spring) that causes localized problems with both ground and surface waters, particularly with respect to high boron content. Except for the one minor tributary (Sulphur Creek) affected by this spring, the sampled surface waters in the basin are of excellent chemical quality.

Ground Water

The South Fork Eel River Basin contains only one area of significant ground water resources - Laytonville Valley. About one-half of the present water requirements in this valley are met from ground water pumping. The average depth to ground water in the valley is less than 10 feet, and usable ground water storage capacity, from a depth of 10 feet to 120 feet, is estimated to be about 21,000 acre-feet. The recharge potential with lowered ground water levels is estimated at over 10,000 acre-feet.

The adjacent Eel River Delta area, which could be served water from the South Fork, contains the largest ground water basin in the Eureka area. Ground water pumpage in this area, including the lower Van Duzen River Valley, is estimated to be over 10,000 acre-feet per year. Total usable ground water storage in the area was estimated to be 136,000 acre-feet.

TABLE 5

SUMMARY OF MEAN SEASONAL RUNOFF
IN THE SOUTH FORK EEL RIVER BASIN
(1910-11 through 1959-60)

Station or Incremental Area	Drainage Area (Square Miles)	Mean Precipitation (Inches)	Mean Loss (Inches)	Mean Annual Runoff (Inches)	Mean Annual Runoff (Acre-Feet)
Standley Damsite	7.1	76.0	31.4	44.6	16,900
Incremental Area	36.8	76.0	27.8	48.2	94,600
South Fork Eel River near Branscomb	43.9	76.0	28.4	47.6	111,500
Tenmile Creek near Laytonville 1/	50.3	70.2	36.1	34.1	91,400
Lost Man Damsite	25.6	69.1	26.8	42.3	57,800
Panther Damsite	74.0	70.5	33.0	37.5	147,900
Frost Damsite	15.4	77.6	30.1	47.5	39,000
Incremental Area	328.3	71.7	30.2	41.5	726,900
South Fork Eel River near Miranda	537.5	71.8	30.8	41.0	1,174,700
Bull Creek near Weott 2/	28.1	77.5	22.0	55.5	83,000
Incremental Area	124.2	67.0	22.0	45.5	298,000
TOTAL South Fork Eel River Basin	689.8	71.2	28.9	42.3	1,555,700

1/ Equivalent to runoff at Cahto Damsite.
2/ Estimated from four years of record.

TABLE 6

ESTIMATED MONTHLY DISTRIBUTION OF RUNOFF
AT SELECTED STATIONS IN THE SOUTH FORK EEL RIVER BASIN
(1910-11 through 1959-60)

Month	S. F. EEL RIVER NEAR BRANSCOMB		TENMILE CREEK NEAR LAYTONVILLE		S. F. EEL RIVER NEAR MIRANDA	
	Acre-Feet	Percent	Acre-Feet	Percent	Acre-Feet	Percent
Oct.	900	0.8	800	0.9	10,800	0.9
Nov.	6,400	5.7	5,300	5.8	65,800	5.6
Dec.	18,000	16.1	14,400	15.8	187,000	15.9
Jan.	26,700	23.9	24,500	26.8	279,700	23.8
Feb.	25,200	22.6	19,700	21.5	268,000	22.8
Mar.	17,000	15.3	14,900	16.3	178,200	15.2
Apr.	10,500	9.4	7,900	8.6	112,000	9.5
May	4,400	3.9	3,000	3.3	46,100	3.9
June	1,500	1.4	800	0.9	16,400	1.4
July	500	0.5	100	0.1	5,500	0.5
Aug.	200	0.2	0	0.0	2,700	0.3
Sept.	200	0.2	0	0.0	2,300	0.2
TOTAL	111,500	100.0	91,400	100.0	1,174,700	100.0

TABLE 7

RESOURCES AGENCY OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
NORTHERN DISTRICT

RUNOFF OF SOUTH FORK EEL RIVER AT STANDLEY DAMSITE

INDEX NO. F64340 TYPE OF RECORD-UNIMPAIRED SOURCE OF RECORD ESTIMATED
LOCATION UNIT ACRE FT.
SW1/4,SW1/4, SEC33 T21N R15W M.D.B.M. AREA 7.1 SQ. MILES

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1911	0	100	500	4900	3200	2200	1600	900	400	100	0	0	13900
1912	0	100	200	3600	1800	2800	1100	2300	400	100	100	200	12700
1913	100	3000	2600	6300	1500	1300	2100	500	200	100	0	0	17700
1914	0	400	3600	13700	3800	1400	2000	1400	200	100	0	0	26600
1915	100	1900	4800	6100	5600	4000	2700	400	200	100	0	100	26000
1916	100	1700	3600	5000	5100	3500	2800	1100	300	100	0	0	23300
1917	0	200	1500	2000	4800	2400	2600	700	200	100	0	0	14500
1918	0	100	700	500	2800	2400	1200	200	100	0	0	0	8000
1919	0	200	600	4700	5700	4100	1400	500	100	0	0	0	17300
1920	0	0	900	200	100	1500	1900	300	100	0	0	0	5000
1921	100	5000	7000	4900	4000	2300	700	400	200	0	0	0	24600
1922	0	200	1500	900	4300	2800	2000	900	200	0	0	0	12800
1923	0	200	2600	2800	1200	500	1800	300	100	0	0	0	9500
1924	0	0	300	700	1800	200	200	0	0	0	0	0	3200
1925	400	2200	2800	1700	9500	1400	3600	1000	300	100	0	0	23000
1926	0	200	1000	1400	7000	1000	400	300	100	0	0	0	11400
1927	100	3400	3300	3700	8500	2700	1900	500	200	100	0	0	24400
1928	0	1300	1200	2800	2200	3900	2900	500	700	0	0	0	15500
1929	0	400	1300	1000	1800	800	1000	400	200	0	0	0	6900
1930	0	0	3200	3000	2600	1900	700	400	100	0	0	0	11900
1931	0	100	200	2600	700	1800	300	100	100	0	0	0	5900
1932	100	600	3700	3200	1400	1200	1100	800	200	100	0	0	12400
1933	0	0	800	2400	1900	4600	1100	1300	400	100	0	0	12600
1934	0	100	2000	2500	1400	1600	700	400	100	0	0	0	8800
1935	100	1900	1500	4700	1300	2900	3400	600	200	0	0	0	16600
1936	0	100	800	9200	5200	1400	1100	300	300	100	0	0	18500
1937	0	0	100	400	4100	3600	3000	700	300	100	0	0	12300
1938	100	4800	5300	2900	8900	7900	1700	800	300	100	0	0	32800
1939	0	300	2500	1400	2300	2300	300	300	100	0	0	0	9500
1940	0	0	2000	5700	7900	4600	1900	400	100	100	0	0	22700
1941	100	300	5500	7300	4400	3300	2900	1000	300	100	100	0	25300
1942	0	200	7300	4400	6400	800	1800	1400	700	200	100	0	23300
1943	0	1100	3800	7100	2100	1800	1400	500	400	100	0	0	18300
1944	200	200	300	1800	1900	2100	700	500	300	100	0	0	8100
1945	0	1800	3000	1600	4800	2700	1100	800	300	100	0	0	16200
1946	0	2700	8900	3400	1700	1700	700	300	100	0	0	0	19500
1947	0	600	800	4400	1600	3200	900	200	200	100	0	0	12000
1948	800	600	400	4200	1800	2300	3800	1100	500	200	100	100	15900
1949	100	700	3000	1400	3900	4900	600	300	100	100	0	0	15100
1950	0	200	300	5700	2600	3800	1000	400	200	100	0	0	14300
1951	1800	2000	4400	7700	4700	2200	400	500	100	100	0	0	23900
1952	200	1600	7600	6400	5200	2400	600	400	200	100	0	0	24700
1953	0	100	5300	10800	700	3300	1200	1200	700	200	100	100	23700
1954	100	2400	2400	8600	2800	2400	3000	300	200	100	100	0	22400
1955	100	1000	2200	2400	600	700	1700	800	200	100	0	0	9800
1956	0	1000	12200	8800	5300	1700	300	300	100	100	0	0	29800
1957	500	400	200	1900	3400	4900	1400	2500	500	200	100	100	16100
1958	1000	2500	5100	5600	10800	3200	4000	300	200	100	0	0	32800
1959	0	200	400	5200	4100	1100	800	200	100	0	0	0	12100
1960	0	0	100	1100	7700	4500	1200	1200	500	100	0	0	16400
1961	0	1000	3500	1200	4800	4100	1000	1300	300	100	100	0	17400
1962	100	500	1700	1700	3800	2900	600	200	100	0	0	0	11600
1963	2600	1300	3600	1100	2800	2000	5700	600	200	100	0	0	20000
1964	100	3600	1100	5400	900	1100	500	200	100	0	0	0	13000
TOTAL	8900	54500	145200	214100	201200	138100	86500	35200	13000	3900	800	600	902000
MEAN	200	1000	2700	3900	3700	2600	1600	700	200	100	0	0	16700
PERCENT	1.2	6.0	16.2	23.2	22.2	15.6	9.6	4.2	1.2	0.6	0.0	0.0	100.0
MEAN COMPUTED FOR PERIOD 1911 to 1960													
	100	1000	2700	4100	3800	2600	1600	700	200	100	0	0	16900
CFS	2	17	44	66	68	42	27	11	3	2	0	0	

TABLE 8

RESOURCES AGENCY OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
NORTHERN DISTRICT

RUNOFF OF S. F. EEL RIVER NEAR BRANSCOMB

INDEX NO F64300 TYPE OF RECORD-UNIMPAIRED SOURCE OF RECORD USGS
LOCATION 39 43.1--123 39.1 UNIT ACRE FT.
1/4,NW1/4, SEC32 T22N R16W M.D.B.M. AREA 43.9 SQ. MILES

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1911	300	800	3100	32700	21000	14600	10400	5900	2400	500	200	100	92000
1912	100	400	1000	24200	11900	18900	7600	15000	2700	800	400	1000	84000
1913	600	20000	17500	41700	10000	8700	13900	3200	1400	600	200	200	118000
1914	100	2600	24000	91100	25600	9300	13400	9600	1300	400	300	300	178000
1915	700	12700	32200	40500	37000	26800	18000	2900	1000	500	300	400	173000
1916	700	11200	23700	33200	33700	23000	18900	7300	2200	500	300	300	155000
1917	100	1200	9700	12900	32100	15800	17200	4600	1500	500	200	200	96000
1918	100	700	4700	3500	18600	15800	8300	1500	500	100	100	100	54000
1919	100	1300	4100	31300	38000	27500	9300	3100	800	300	100	100	116000
1920	100	200	5900	1400	600	9500	12900	2200	700	300	100	100	34000
1921	700	33000	46400	32600	26600	15000	4600	2400	1100	300	200	100	163000
1922	200	1000	10100	6200	28800	18800	13300	5700	1400	200	200	100	86000
1923	200	1000	17300	18400	7900	3000	11900	2100	700	300	100	100	63000
1924	200	100	2300	4600	11800	1600	1000	300	100	0	0	0	22000
1925	2900	14400	18900	11500	63300	9600	23800	6600	2000	500	200	300	154000
1926	300	1200	6700	9100	46400	6800	2800	2100	400	100	100	0	76000
1927	500	22700	22300	24500	56600	17700	12900	3000	1100	400	200	100	162000
1928	0	8800	8200	18900	14900	25800	19500	3600	900	300	100	0	101000
1929	100	2700	8600	6700	11700	5100	6500	2800	1400	300	100	0	46000
1930	100	0	21600	19800	17400	12500	4500	2800	800	300	100	100	80000
1931	200	700	1000	17300	4900	12100	2300	800	500	100	100	0	40000
1932	800	4200	24400	21400	9500	8200	7000	5600	1200	400	200	100	83000
1933	100	300	5500	15800	12700	30600	7400	8700	2900	600	200	200	85000
1934	0	400	13500	16700	9200	10600	4700	2500	800	300	200	100	59000
1935	400	12800	9900	31200	8900	19000	22900	4300	1100	300	100	100	111000
1936	300	400	5600	61500	34700	9100	7500	2200	2000	400	200	100	124000
1937	100	100	400	2500	27300	24000	20000	4400	2300	600	200	100	82000
1938	400	32000	35400	19400	59100	52500	11500	5300	1700	400	200	100	218000
1939	300	1900	16400	9500	15400	15300	2300	1700	700	300	100	100	64000
1940	100	100	13100	37900	52700	30900	12800	2800	900	400	200	100	152000
1941	400	1900	36800	48600	29200	21800	19100	6400	2300	800	400	300	168000
1942	200	1500	48400	29000	42900	5500	11900	9600	4400	1000	400	200	155000
1943	200	7400	25400	47400	14200	12200	9100	3500	2600	600	300	100	123000
1944	1100	1500	2000	12100	12500	14100	4900	3200	1700	600	200	100	54000
1945	100	12100	19700	10600	31900	17700	7100	5100	1900	500	200	100	107000
1946	200	18200	59500	22400	11000	11000	4600	1800	700	300	200	100	130000
1947	200	4300	5000	2400	10800	21200	6100	1400	1600	500	200	100	53800
1948	5400	3800	2800	28200	12200	15400	25300	7600	3500	1200	500	500	106400
1949	900	4400	21100	9200	26100	32700	3700	1700	700	400	200	100	101200
1950	200	1000	1900	37700	17600	25200	8000	2600	1100	400	200	100	96000
1951	12000	13600	29500	51000	31200	14600	2400	3500	900	500	200	100	159500
1952	1000	10800	50700	42600	34800	16300	3700	2900	1400	700	300	200	165400
1953	100	900	35600	72000	4600	22200	7700	8300	4400	1300	700	400	158200
1954	700	15700	16000	57500	18400	16300	19900	2300	1300	600	400	300	149400
1955	600	6400	14700	15700	4200	4800	11500	5100	1200	600	300	200	65300
1956	300	6800	81000	58500	35100	11500	2300	2200	900	400	200	200	199400
1957	3200	2500	1400	12800	22700	32900	9300	16600	3000	1100	500	500	106500
1958	7100	16800	33900	37200	72100	21200	26700	2000	1200	600	200	200	219200
1959	200	1600	2800	34500	27300	7400	5100	1400	700	300	100	300	81700
1960	300	200	600	7400	51400	29800	8200	8100	3100	700	300	200	110300
1961	300	6700	23200	8300	32000	27500	6500	8900	1900	700	400	200	116600
1962	500	3000	11300	11400	25300	19300	3700	1600	700	200	300	200	77500
1963	17100	8300	24100	7500	18700	13000	37900	4000	1300	800	300	200	133200
1964	800	24000	7000	36300	6000	7400	3100	1600	800	300	200	100	87600
TOTAL	63900	362300	967900	1398300	1340500	919100	576900	236400	81800	26100	12400	9600	5995200
MEAN	1200	6700	17900	25900	24800	17000	10700	4400	1500	500	200	200	111000
PERCENT	1.1	6.0	16.1	23.3	22.3	15.3	9.6	4.0	1.4	0.5	0.2	0.2	100.0
MEAN COMPUTED FOR PERIOD 1911 to 1960													
	900	6400	18000	26700	25200	17000	10500	4400	1500	500	200	200	111500
CFS	15	107	290	431	450	274	175	71	25	8	3	3	

TABLE 9

RESOURCES AGENCY OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
NORTHERN DISTRICT

RUNOFF OF TENMILE CREEK NEAR LAYTONVILLE*

INDEX NO. F64400 TYPE OF RECORD-UNIMPAIRED SOURCE OF RECORD USGS
LOCATION 39 45.8--123 32.5 UNIT ACRE FT.
SW1/4,NW1/4,SEC16 T22N R15W M.D.B.M. AREA 50.3 SQ. MILES

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1911	200	600	2300	27900	15000	12200	7000	3800	1200	100	0	0	70300
1912	100	300	700	20900	8600	16000	5300	9900	1400	200	100	200	63700
1913	400	15900	13500	37400	7500	7700	10000	2200	700	100	0	0	95400
1914	100	2200	19800	87100	20300	8700	10200	7000	800	100	100	100	156500
1915	500	11100	27300	39700	30300	25700	14100	2200	600	100	100	100	151800
1916	500	9600	19800	32100	27200	21800	14600	5500	1200	100	100	100	132600
1917	100	1000	7500	11500	23800	13600	12200	3100	800	100	0	0	73700
1918	100	500	3200	2800	12300	12200	5300	900	200	0	0	0	37500
1919	100	1100	3100	27900	28100	23900	6600	2100	400	100	0	0	93400
1920	100	100	3900	1000	400	7200	8000	1200	300	100	0	0	22300
1921	500	29500	37900	31700	21700	14200	3600	1800	300	100	0	0	141300
1922	100	800	7600	5500	21000	16000	9200	3800	700	0	0	0	64700
1923	0	700	12100	14900	5400	2500	7700	1300	300	100	0	0	45000
1924	100	0	1400	3100	6600	1100	600	100	0	0	0	0	13000
1925	2100	12900	16500	11600	53400	9500	19200	5100	1100	100	0	100	131600
1926	100	900	5000	7800	32900	5700	1900	1400	200	0	0	0	55900
1927	300	19800	18800	24100	46500	17100	10200	2300	600	100	0	0	139800
1928	0	6800	6200	16500	10800	22000	13600	2400	500	100	0	0	78900
1929	100	1800	5800	5300	7700	3900	4100	1700	600	100	0	0	31100
1930	0	0	15400	16400	12000	10100	3000	1800	400	100	0	0	59200
1931	100	500	700	11900	2800	8200	1300	400	200	0	0	0	26100
1932	500	3200	17800	18200	6700	6800	4700	3700	600	100	0	0	62300
1933	0	200	4000	13300	8900	25300	5000	5600	1400	100	0	0	63800
1934	0	300	9000	13100	5900	8200	2900	1600	400	100	0	0	41500
1935	300	10100	7600	28000	6600	16500	16300	2900	600	100	0	0	89000
1936	200	400	4300	54800	25800	7900	5300	1500	1000	100	0	0	101300
1937	100	100	300	2200	20100	20800	14000	3000	1100	100	0	0	61800
1938	300	29200	31400	20000	50800	52900	9400	4200	1000	100	0	0	199300
1939	200	1400	11400	7700	10300	11800	1500	1100	400	100	0	0	45900
1940	100	0	10700	36100	41900	28700	9700	2000	700	100	100	0	130100
1941	400	1600	27700	44700	21000	18700	13700	4100	1200	200	100	100	133500
1942	300	1600	41700	27800	36000	4800	10600	7900	2800	300	100	100	134000
1943	200	7300	22100	41300	9900	10700	6600	2900	1900	200	100	0	103200
1944	800	1000	1100	10700	8400	9300	2400	1500	700	100	0	0	36000
1945	200	11500	14700	8800	22400	14400	5000	3800	1000	200	100	0	82100
1946	1000	14000	48300	20700	9800	10400	3600	1100	400	100	0	0	109400
1947	200	3200	3400	1700	6900	17100	3900	1000	600	100	0	0	38100
1948	2400	2200	1700	28200	7400	13700	18800	5300	1600	300	100	100	81800
1949	400	2400	12100	8000	16800	33600	3200	1500	500	100	100	0	78700
1950	200	600	1200	27000	13300	18500	6300	1900	600	100	0	0	69700
1951	11500	11300	29600	45600	27800	12200	2000	2100	500	100	100	0	142800
1952	600	8500	40100	40000	30400	15400	3400	2100	700	200	100	0	141500
1953	200	700	30900	66600	4600	19100	5900	5800	2300	400	100	100	136700
1954	500	9900	9300	58500	17400	17500	14900	1800	700	200	100	100	130900
1955	400	4700	11900	13800	3400	3600	9000	3200	700	100	100	0	50900
1956	300	5200	65100	59900	32200	12700	2200	1600	600	100	100	0	180000
1957	1600	1300	1000	9900	16600	26800	5600	9200	1400	200	100	100	73800
1958	10200	13900	30300	38300	76200	23900	26300	1800	800	200	100	0	222000
1959	100	700	2500	32700	28300	6500	3200	900	300	0	0	100	75300
1960	100	200	500	10200	22900	16900	5000	6900	1600	300	100	0	64700
1961	200	5000	18500	11300	28200	28000	5600	5300	900	200	100	100	103400
1962	200	3200	8500	8000	26600	19100	2700	1000	400	100	100	100	70000
1963	12900	7500	19200	14700	20100	16700	32300	3400	700	200	100	100	127900
1964	400	19800	5400	28200	5000	6600	1900	1000	500	100	0	0	68900
TOTAL	52600	298300	771800	1287100	1062900	814400	430600	162700	43100	6700	2300	1600	4934100
MEAN	1000	5500	14300	23900	19700	15100	8000	3000	800	100	0	0	91400
PERCENT	1.1	6.0	15.6	26.1	21.6	16.5	8.8	3.3	0.9	0.1	0.0	0.0	100.0
MEAN COMPUTED FOR PERIOD 1911 to 1960													
	800	5300	14400	24500	19700	14900	7900	3000	800	100	0	0	91400
CFS	13	88	232	395	352	240	132	48	13	2	0	0	

* Equivalent to runoff at Cahto damsite.

TABLE 10

RESOURCES AGENCY OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
NORTHERN DISTRICT

RUNOFF OF EAST BR. S. F. EEL RIVER AT PANTHER DAMSITE

INDEX NO. F64160 TYPE OF RECROD-UNIMPAIRED SOURCE OF RECORD ESTIMATED
LOCATION UNIT ACRE FT.
SE1/4, NE1/4,SEC31 T04S R04E H.B.M. AREA 74.0 SQ. MILES

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1911	400	1100	4100	42700	27500	19100	13600	7700	3200	600	300	200	120500
1912	100	600	1300	31900	15700	24800	10100	19700	3600	1100	500	1300	110700
1913	900	26600	23300	55300	13300	11600	18500	4200	1800	800	300	200	156800
1914	200	3400	32500	123200	34600	12700	18100	13000	1800	600	400	400	240900
1915	900	17200	43800	54900	50100	36400	24400	3900	1300	700	400	500	234500
1916	1000	15100	31900	44600	45200	30900	25400	9900	3000	700	400	500	208600
1917	200	1600	12700	16900	41800	20600	22400	6000	2000	600	300	200	125300
1918	200	900	6000	4500	24100	20500	10800	2000	600	200	100	100	70000
1919	100	1800	5400	41600	50500	36600	12300	4100	1000	400	200	100	154100
1920	200	300	7700	1800	800	12500	17100	2900	900	500	100	100	44900
1921	1000	46500	61300	44200	36400	20200	6300	3200	800	300	200	200	220600
1922	200	1400	13100	8100	37600	24400	17300	7400	1800	300	200	200	112000
1923	0	1300	22500	23900	10200	4000	15600	2800	1000	400	200	200	82100
1924	300	0	3000	5800	15100	2000	1300	300	0	0	0	0	27800
1925	3900	19300	25500	15500	85200	13000	32000	8800	2700	600	300	400	207200
1926	200	1600	8700	11900	60300	8800	3600	2800	500	200	100	0	98700
1927	700	30600	30000	33000	76200	23900	17400	4100	1500	500	200	100	218200
1928	0	11600	10900	24900	19500	33900	25700	4800	1200	400	100	100	133100
1929	200	3500	11100	8700	15100	6600	8500	3600	1700	400	200	100	59700
1930	100	100	28000	25600	22500	16100	5900	3600	1100	300	200	200	103700
1931	200	900	1300	22200	6200	15400	3000	1000	600	200	100	100	51200
1932	1100	5500	31900	28100	12500	10700	9100	7300	1600	500	200	100	108600
1933	100	300	7200	20500	16600	39800	9600	11400	3800	800	300	100	110500
1934	100	600	17400	21600	11800	13800	6000	3300	1100	400	200	100	76400
1935	600	17000	13200	41500	11700	25300	30500	5800	1400	400	200	100	147700
1936	400	600	7400	81900	46300	12100	10000	2900	2700	600	300	100	165300
1937	100	100	500	3300	36000	31600	26300	5800	3000	700	200	200	107800
1938	600	43600	48300	26300	80500	71500	15600	7300	2300	600	200	100	296900
1939	400	2500	21400	12400	20000	19900	3000	2200	1000	400	200	100	83500
1940	100	100	17700	50900	71100	41500	17200	3700	1600	700	400	300	205300
1941	800	2500	44500	62200	34800	26600	23900	7400	2900	1300	700	500	208100
1942	600	2600	64900	37000	57700	6500	17900	13900	6700	1700	800	500	210800
1943	500	12300	38000	59800	16900	16000	12100	5700	4800	1300	500	300	168200
1944	2000	1900	2000	17900	16700	15500	4800	3000	2000	800	400	300	67300
1945	500	19200	24600	12700	38500	21100	8900	7300	2500	1100	500	300	137200
1946	2300	22100	80400	29300	17000	15100	6400	2000	1100	600	300	300	176900
1947	400	6000	6500	2700	13400	28600	8000	2200	1800	800	400	300	71100
1948	4900	3400	2800	41300	12400	20400	34300	10100	4100	1700	800	700	136900
1949	900	4000	20700	12100	30200	53300	6100	2900	1200	700	400	200	132700
1950	400	1000	2200	41200	25200	29300	12600	4000	1500	700	400	300	118800
1951	23200	17400	48000	62000	46100	16900	3300	3700	1200	700	400	300	223200
1952	1100	13200	64600	55300	51000	21900	6100	3700	1800	1000	500	400	220600
1953	400	1100	51500	94900	8100	27600	10500	10700	5700	2000	1000	600	214100
1954	1100	15500	15000	84700	30500	26100	26700	3400	1700	1000	600	600	206900
1955	800	8200	21800	21200	6400	5700	17700	6500	1800	800	400	400	91700
1956	500	7800	102100	81300	52900	17800	3900	2800	1300	700	400	300	271800
1957	3400	2000	1800	14300	29100	39600	10100	17400	3700	1100	600	1000	124100
1958	9600	16800	33500	45800	100400	28100	39800	3300	1400	800	500	400	280400
1959	300	1400	3500	48000	39500	10000	6400	2200	900	500	300	800	113800
1960	400	400	900	8700	60300	35000	9600	12900	4700	1400	600	400	135300
1961	500	8000	30100	10900	43900	33200	9800	9900	2500	1100	600	500	151000
1962	600	3800	13300	11800	37000	21800	4900	2500	900	500	500	400	98000
1963	24500	10900	26700	10800	32200	20500	47000	6900	2000	1100	600	500	183700
1964	2400	29700	7700	42600	7700	8400	3700	1900	1100	600	400	300	106500
TOTAL	96600	466900	1256200	1836200	1802300	1205200	771100	311800	109900	38900	19600	17000	7931700
MEAN	1800	8600	23300	34000	33400	22300	14300	5800	2000	700	400	300	146900
PERCENT	1.2	5.9	15.9	23.1	22.7	15.2	9.7	3.9	1.4	0.5	0.3	0.2	100.0
MEAN COMPUTED FOR PERIOD 1911 to 1960													
	1400	8300	23600	35200	33600	22400	14100	5800	2100	700	400	300	147900
CFS	23	138	381	568	600	361	235	94	35	11	6	5	

TABLE 11

RESOURCES AGENCY OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
NORTHERN DISTRICT

RUNOFF OF SOUTH FORK EEL RIVER NEAR MIRANDA

INDEX NO. F64100 TYPE OF RECORD-UNIMPAIRED SOURCE OF RECORD USGS
LOCATION 40 10.9--123 46.5 UNIT ACRE FT.
1/4,NW1/4,SEC30 T3S R4E R.B.M. AREA 537 SQ. MILES

YEAR	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	TOTAL
1911	3200	8500	32200	337400	217200	151300	107400	60800	25300	4800	2400	1500	952000
1912	1100	4500	10200	251800	124200	196100	79500	156000	28500	8400	3700	10000	874000
1913	6700	209900	183700	436900	105300	91400	146100	33500	14400	6000	2300	1800	1238000
1914	1600	27200	255900	97100	272400	99700	142700	102200	14200	4600	3300	3200	1898000
1915	7300	135200	344700	432400	394800	286600	192400	31000	10500	5500	3500	4100	1848000
1916	7700	118700	251500	352000	356700	244000	200200	77800	23700	5600	3500	3600	1645000
1917	1400	12700	100600	133500	330500	162600	177500	47400	15800	5100	2300	1600	991000
1918	1400	6900	47900	35600	190900	162300	85400	15500	5100	1400	800	800	554000
1919	900	13900	42800	328400	398500	288800	97200	32600	7900	2800	1500	700	1216000
1920	1500	2000	61000	14200	6400	98800	135000	22600	6900	3600	1100	900	354000
1921	7800	365200	484200	348100	286500	159600	49600	25400	6500	2100	1700	1300	1738000
1922	1800	10700	104000	64200	297300	193200	136900	58400	14600	2100	1600	1200	886000
1923	200	10300	178100	188800	81100	31600	123000	21800	7500	3000	1400	1200	648000
1924	2400	400	23600	46200	119400	16100	10400	2700	400	100	100	200	222000
1925	30900	152600	200700	121900	671700	102100	252500	69600	21500	4800	2300	3400	1634000
1926	1900	12400	68900	93900	477200	69400	28800	22000	4100	1300	800	300	781000
1927	5300	241400	236900	260500	601100	188600	137100	32300	12100	4300	1600	800	1722000
1928	200	91500	85800	196600	154500	268000	203100	37800	9300	3000	800	400	1051000
1929	1200	27400	88000	68700	119500	51900	67000	28700	13800	3200	1200	400	471000
1930	700	500	221500	202900	178000	127600	46700	28500	8300	2700	1400	1200	820000
1931	1500	7100	10600	175600	49200	122400	23600	7600	5000	1300	600	500	405000
1932	8300	43500	252300	221800	98700	84500	72200	57700	12500	4000	1800	700	858000
1933	800	2600	56900	162200	131100	315200	75900	89900	30300	6600	2300	1200	875000
1934	400	4400	137800	171000	93700	109000	47700	25800	8300	3500	1600	800	604000
1935	4400	134200	104000	327900	92800	199600	240900	45400	11200	3300	1300	1000	1166000
1936	2800	4600	58600	646400	365500	95300	78800	23000	21400	4700	2000	900	1304000
1937	1000	700	4300	26000	284200	249900	207500	45500	24000	5800	1900	1200	852000
1938	4700	343100	380100	207600	633800	563400	122800	57300	18200	4400	1800	800	2338000
1939	2800	19500	168900	98100	158400	157200	24000	17600	7800	2800	1300	600	659000
1940	900	500	139200	401700	560300	327300	135800	29400	12500	5400	2900	2500	1618400
1941	5900	19700	354600	493100	278100	211900	189500	59600	22800	9800	5600	3900	1654500
1942	4300	20000	512200	293300	455000	52100	139800	109000	51900	12900	6000	3700	1660200
1943	3800	95400	296500	474300	135200	126800	95500	44100	36800	9700	4200	2500	1324800
1944	15100	14800	16600	139900	131800	124600	39000	24600	16000	6300	3300	2200	534200
1945	4000	149300	195500	101000	307100	168100	70500	57400	20000	8300	4000	2400	1087600
1946	16400	176400	633500	232000	132200	119200	50500	16400	8600	4500	2400	1900	1394000
1947	2900	47200	51100	22000	106700	225800	63300	17200	14100	5900	3300	2200	561700
1948	40400	28200	23100	323000	100800	160900	270500	79700	32900	13000	6500	5400	1084400
1949	7000	33100	169300	95800	241800	413200	47500	22100	9400	5100	3000	1700	1049000
1950	3000	8300	17400	332100	197900	234400	98300	31100	12000	5500	2900	2000	944900
1951	177400	138000	372300	494100	360700	135400	26300	29600	9700	5200	2900	2400	1754000
1952	8600	104800	512000	437400	399300	172700	47000	29300	13900	8100	3700	2700	1739500
1953	2900	8800	403600	750100	62100	219600	82800	85000	45300	15700	7600	4900	1688400
1954	8500	126300	122800	662600	236300	203000	210600	26800	13300	7500	4600	4700	1627000
1955	6200	64800	170200	167200	50200	45400	138100	51700	14300	6200	3400	2900	720600
1956	4000	62600	810300	638900	413100	138700	30000	22400	10400	5200	3200	2500	2141300
1957	27400	16800	14000	114800	230900	315500	81400	140600	29600	9200	5000	7500	992700
1958	85800	150500	303500	402900	865200	245600	337300	27200	12200	6800	3600	2900	2443500
1959	2500	12100	30600	410100	337600	85300	53800	18200	7400	4100	2300	6200	970200
1960	3500	3000	7600	79400	505000	296900	81900	107200	38100	10900	5000	3100	1141600
1961	4000	68800	256900	97800	373800	292700	82000	85000	21000	8400	4700	4000	1299100
1962	4800	33500	114500	103900	316200	193800	41600	20300	7400	4100	4000	2900	847000
1963	204900	93500	234000	99200	269100	175900	405600	56800	16600	8900	5000	3900	1573400
1964	18600	255900	67500	368800	66200	74300	31100	16000	9000	5000	3200	2000	917600
TOTAL	774700	3743900	10024500	14657000	14423200	9645300	6161600	2483100	874300	302500	154200	129300	63373600
MEAN	14300	69300	185600	271500	267100	178600	114100	46000	16200	5600	2900	2400	1173600
PERCENT	1.2	5.9	15.8	23.2	22.8	15.2	3.9	3.9	1.4	0.5	0.2	0.2	100.0
MEAN COMPUTED FOR PERIOD 1911 to 1960													
	10800	65800	187000	279700	268000	178200	112000	46100	16400	5500	2700	2300	1174500
CFS	174	1100	3020	4510	4790	2870	1870	744	273	89	44	38	

Water Requirements

A principal consideration in this study was the development of a water supply to meet local needs for irrigation, urban, industrial, and recreation purposes. It was not within the scope of this study to make a thorough evaluation of the economic demand for water in the South Fork Basin and the Eel River Delta. However, estimates of the amounts of water required for the economic growth of communities in the North Coastal area have been the subject of major studies in recent years. The South Fork Eel River Study relied heavily on the previous studies in evaluating the water conservation potential of proposed projects. Department of Water Resources Bulletins No. 142-1, 94-8, and 160-66 were the principal sources of data for the period 1960-2020. Additional projections were made for this study for the period 2020-2070.

The objective of the water requirement estimates in this study was the economic evaluation of water conserved for use by proposed projects within the South Fork Basin. The methods of determining total water requirements in the study area for the four categories of use are described in the following sections. To arrive at an estimate of the potential demand for water conserved by projects, the total water requirements were reduced substantially. The reduction represents the continued use of existing water developments and a rough estimate of future non-project water supply to be developed within the study area. Projected total water requirements and the estimated demand for project yield (project demand) are presented in Table 12.

Urban Water Requirements

Water required for urban development within the study area was estimated from the population projections presented earlier in this chapter. The per capita consumption of water was estimated to increase from 140 gallons per person per day in 1970 to 160 gallons in 2020 and remain at that level through 2070. These values multiplied by the projected subunit population determined the urban water requirement of the study area.

SERVICE AREA WATER REQUIREMENTS
BY SUBUNIT AND DEMAND FOR PROJECT YIELD

(In Acre-Feet)

YEAR AND PURPOSE	LAYTONVILLE		LAKE BENBOW		HUMBOLDT REDWOODS		LOWER EEL		SOUTH FORK BASIN TOTAL		STUDY AREA TOTAL	
	TOTAL REQUIRED	PROJECT DEMAND	TOTAL REQUIRED	PROJECT DEMAND	TOTAL REQUIRED	PROJECT DEMAND	TOTAL REQUIRED	PROJECT DEMAND	TOTAL REQUIRED	PROJECT DEMAND	TOTAL REQUIRED	PROJECT DEMAND
1960												
Agricultural	430	0	390	0	170	0	19000	0	990	0	20000	0
Urban	100	0	600	0	300	0	2800	0	1000	0	3800	0
Recreation	0	0	100	0	100	0	100	0	200	0	300	0
Industrial	0	0	0	0	0	0	0	0	0	0	0	0
1970												
Agricultural	800	0	650	0	220	0	23500	0	1700	0	25100	0
Urban	100	0	700	0	400	0	3300	300	1200	0	4500	300
Recreation	0	0	180	0	230	0	100	0	410	0	510	0
Industrial	0	0	0	0	0	0	0	0	0	0	0	0
1980												
Agricultural	2000	0	1300	830	440	200	30000	6500	3700	1000	33700	7500
Urban	200	0	1000	300	600	200	4000	1000	1800	500	5800	1500
Recreation	50	50	650	280	850	330	200	0	1600	650	1800	650
Industrial	0	0	0	0	0	0	35000	35000	0	0	35000	35000
1990												
Agricultural	3400	0	1600	1100	500	300	33600	11900	5500	1400	39100	13300
Urban	400	200	1500	800	800	400	5200	2200	2700	1400	7900	3600
Recreation	100	100	1400	780	1700	880	400	100	3200	1800	3600	1900
Industrial	0	0	0	0	0	0	35000	35000	0	0	35000	35000
2000												
Agricultural	4700	0	1400	910	470	240	37800	15400	6600	1200	44400	16600
Urban	400	200	2000	1300	1000	600	7100	4100	3400	2100	10500	6200
Recreation	150	150	2400	1700	2900	1800	700	300	5500	3700	6200	4000
Industrial	0	0	0	0	0	0	35000	35000	0	0	35000	35000
2010												
Agricultural	6000	0	660	440	220	110	37800	15400	6900	550	44700	16000
Urban	400	200	2600	1900	1300	900	9100	6100	4500	3000	13400	9100
Recreation	200	200	3400	2400	4300	2900	1100	600	7900	5500	9000	6100
Industrial	0	0	0	0	0	0	35000	35000	0	0	35000	35000
2020												
Agricultural	7100	0	0	0	0	0	36000	13400	7100	0	43100	13400
Urban	500	300	3300	2600	1500	1100	11500	8500	5300	4000	16800	12500
Recreation	250	250	4400	3200	5700	3900	1600	1000	10400	7400	12000	8400
Industrial	0	0	0	0	0	0	35000	35000	0	0	35000	35000

Note: Urban classification includes business and light industrial use. Industrial classification is based on a projected increase in the pulp and paper industry in the Lower Eel subunit.

Agricultural Water Requirements

Water requirements for irrigated agriculture within the study area were based on present and projected land use data presented in Bulletin No. 142-1. These projections are based on the ability of irrigable land within the study area to produce the crops climatically suited for the area, the present and historical crop pattern, and the market outlets available for agricultural products.

In determining the project demand as described above, the estimates of agricultural water requirements were further modified by excluding the Laytonville area. This was done for two reasons. First, Laytonville Valley is upstream from the proposed projects and 100 to 150 feet higher in elevation; an extensive distribution system and much pumping would be required to deliver irrigation water to the area. Second, Laytonville Valley contains the only ground water basin of significance in the South Fork Eel River drainage. The developable ground water within this basin is estimated to be about 50 percent more than the highest projected annual requirement for agricultural water in the Laytonville subunit.

Recreation Water Requirements

In an area of such special attractiveness as the South Fork Eel River Basin, recreation is a major economic influence and is soon expected to rival the timber industry in importance. The vast influx of recreation seekers to the South Fork Basin each year creates a significant demand for water over and above the year-round urban requirements of the basin.

The water requirements presented in Bulletin 142-1 for recreation within the South Fork Eel River Basin were projected to the year 2070 and modified to include increased recreation use attracted to the basin by surface water developments. The total requirement is determined principally by the water needs of recreation visitors to the basin and the needs of facilities to accommodate these visitors.

Industrial Water Requirements

The normal water requirements for business and light industry are included in the urban classification in Table 12. In the analysis of the Panther Project in Chapter 4, consideration is given to supplying water for an expansion of the pulp and paper industry in the Lower Eel

subunit. The projected water requirement for industrial use is based on the assumption that a 500-ton-per-day pulp mill will be constructed in the Lower Eel subunit in the 1970-80 decade.

CHAPTER 3. GENERAL PLANNING CONSIDERATIONS

The evaluation of proposed water developments within the South Fork Eel River Basin included provisions for local water supply, flood control, recreation, and fishery and wildlife enhancement. The major investigative activities and the criteria for evaluating projects studied during this investigation are set forth in this chapter.

Inventory of Damsites

The first major activity of the South Fork Eel River Study was to make an inventory of the basin to determine the location of possible reservoirs. Initially these reservoir sites were located by inspection of large-scale topographic maps (USGS quadrangles). The sites thus located were checked in the field by a team including an engineer, a geologist, and a recreation planner. The field check eliminated the potential projects with obvious defects and narrowed the scope of the study to the more favorable sites. All damsites defined in the initial inventory are shown in Figure 4 and described in Table 13. The following sections discuss the major tributary stream basins and the more significant of the sites surveyed. Some of the sites that were not selected for detailed analysis in this study may merit reevaluation in the future. These sites are noted in the following descriptions and designated in Figure 4.

Bull Creek Basin

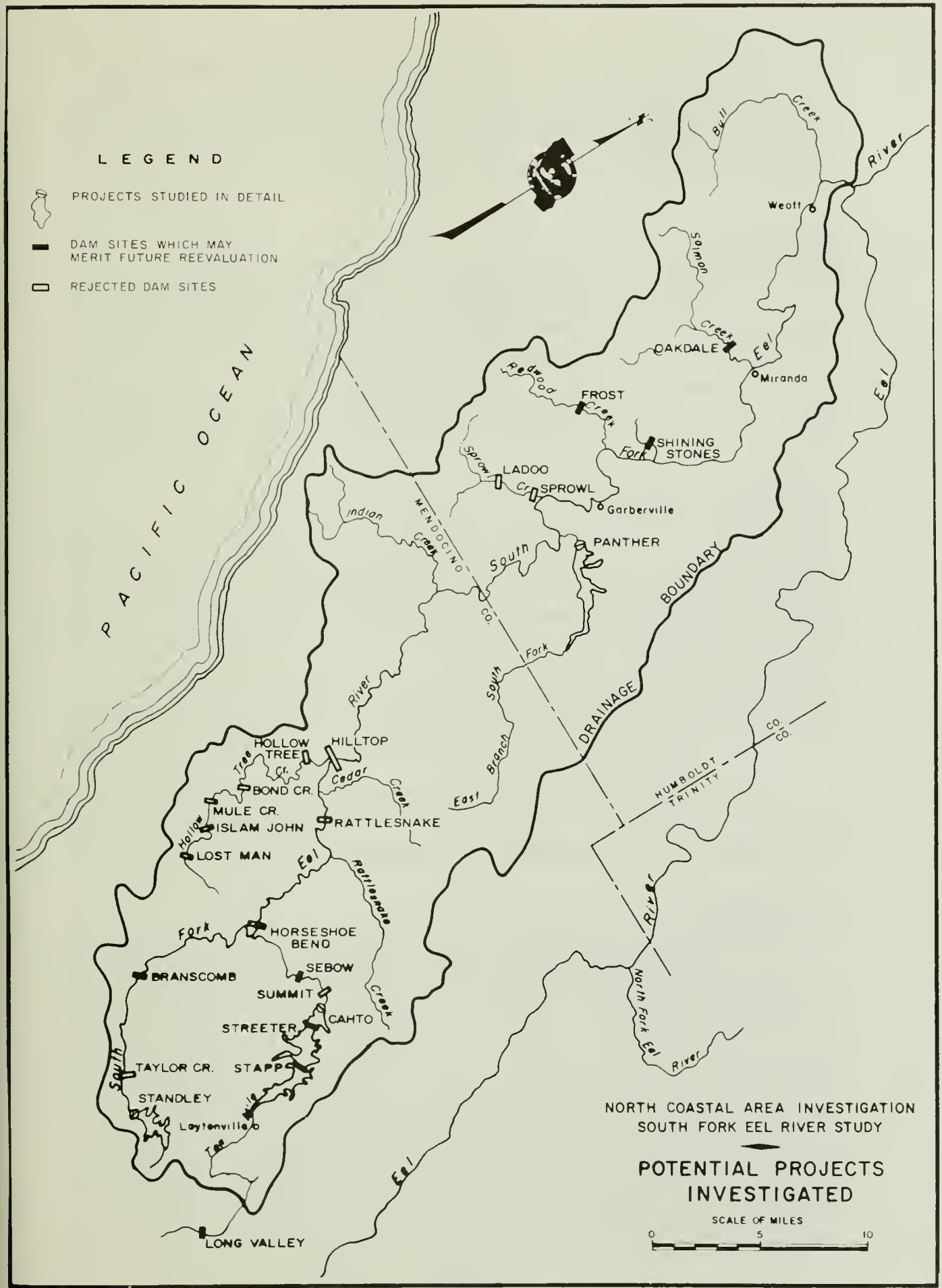
The Department of Parks and Recreation has recently acquired the upper Bull Creek watershed, thus including the entire basin within Humboldt Redwoods State Park. The Department of Water Resources policy is to avoid inundation of any part of the State Park system; therefore, the Bull Creek Basin was not included in this study.

The Department of Parks and Recreation has considered constructing a dam in the upper drainage for sediment and debris control to protect

TABLE 13

DAMSITES CONSIDERED IN THE SOUTH FORK EEL RIVER STUDY

Name	Stream	Damsite Location ¼ Sec.	T	R	Base	Drainage Area (Square Miles)	Estimated Mean Runoff (Acre-Feet)	Stream Elevation (Feet)	Water Elev. (Feet)	Surface Area (Acres)	Maximum Storage (Acre-Feet)
Oakdale	Salmon Creek	SE5	3S	3E	H	33.6	95,000	220	600	1,210	174,000
Shining Stones	Leggett Creek	Ctr.3	4S	3E	H	4.1	8,000	480	600	160	7,000
Frost	Redwood Creek	NW17	4S	3E	H	15.4	39,000	515	700	870	55,000
Sprowl	Sprowl Creek	NW8	5S	3E	H	15.6	43,000	530	700	430	31,000
Ladoo	Sprowl Creek	SW34	4S	3E	H	23.9	57,000	360	600	690	58,000
Panther	East Branch	NE31	4S	4E	H	74.0	147,900	390	600	920	80,200
Hilltop	South Fork Eel	SE10	23N	17W	MD	247.7	540,000	740	1,200	6,010	855,000
Hollow Tree	Hollow Tree Creek	SE16	23N	17W	MD	41.5	93,000	815	1,100	1,080	97,000
Bond Creek	Hollow Tree Creek	SW10	22N	17W	MD	18.1	41,000	1,160	1,300	430	21,000
Mule Creek	Hollow Tree Creek	NE28	23N	17W	MD	38.2	86,000	895	1,200	1,650	139,000
Islam John	Hollow Tree Creek	NE32	23N	17W	MD	30.5	68,000	990	1,300	1,950	166,000
Lost Man	Hollow Tree Creek	NW3	22N	17W	MD	25.6	57,800	1,060	1,300	1,400	101,000
Rattlesnake	South Fork Eel	NW19	23N	16W	MD	179.0	401,000	820	1,200	1,250	190,000
Horseshoe Bend	South Fork Eel	NW16	22N	16W	MD	126.0	284,000	1,200	1,530	4,300	335,000
Sebow	Tenmile Creek	SW18	22N	15W	MD	60.0	113,200	1,378	1,600	3,120	267,000
Cahto	Tenmile Creek	NW16	22N	15W	MD	50.3	91,400	1,425	1,580	1,750	95,500
Summit	Tenmile Creek	SW9	22N	15W	MD	51.5	93,700	1,415	1,600	2,270	146,000
Streeter	Tenmile Creek	NE21	22N	15W	MD	46.1	82,200	1,443	1,600	1,860	114,000
Stapp	Tenmile Creek	NW26	22N	15W	MD	34.9	58,300	1,482	1,600	900	44,000
Branscomb	South Fork Eel	NW4	21N	16W	MD	41.1	105,000	1,405	1,530	760	30,000
Taylor Creek	South Fork Eel	SW25	21N	16W	MD	14.2	34,000	1,586	1,800	700	56,000
Standley	South Fork Eel	SW33	21N	15W	MD	7.1	16,900	1,737	1,880	320	16,500
Long Valley	Long Valley Creek	SW31	21N	14W	MD	4.9	9,000	1,670	1,700	650	10,000
Sherwood	Sherwood Creek	NW10	19N	14W	MD	10.0	22,000	2,150	2,300	2,570	127,000


LEGEND
PROJECTS STUDIED IN DETAIL
DAM SITES WHICH MAY MERIT FUTURE REEVALUATION
REJECTED DAM SITES
PACIFIC OCEAN
Bull Creek
Weott
Eel River
Salmon Creek
OAKDALE
Eel
Miranda
Redwood Creek
FROST
SHINING STONES
Fork
Sprowl Cr.
LADOO
SPROWL
Garberville
Indian Creek
MENDOCINO CO.
PANTHER
South Fork Eel River
BOUNDARY
DRAINAGE
HUMBOLDT CO.
TRINITY CO.
East Branch
HOLLOW TREE
HILLTOP
Tree Cr.
Cedar Creek
BOND CR.
MULE CR.
ISLAM JOHN
RATTLESNAKE
Hollow
LOST MAN
Eel
Rattlesnake Creek
Fork
HORSESHOE BEND
BRANSCOMB
SEBOW
SUMMIT
CAHTO
STREETER
South
TAYLOR CR.
STAPP
STANDLEY
Laytonville
Tree
Eel
LONG VALLEY
Eel River
North Fork Eel River
NORTH COASTAL AREA INVESTIGATION
SOUTH FORK EEL RIVER STUDY
POTENTIAL PROJECTS INVESTIGATED
SCALE OF MILES
0
5
10

the virgin stands of redwoods within Rockefeller Grove. Such a project could be enlarged to include recreation, fishery enhancement, and some local water supply as project purposes. Interested local agencies should contact the Department of Parks and Recreation for information on this proposal.

Oakdale Damsite

This site was dropped from the study during the initial survey due to the prevalence of landslides at the damsite and in the reservoir area. However, a good potential for recreation development exists at the site and it may merit further consideration in the future. The initial phase of any future study should center on detailed evaluation of the landslide problem.

Shining Stones Damsite

This site, on Leggett Creek, was eliminated from the study after considerable study. It is one of the few geologically sound damsites within the basin and is located in an exceptionally scenic area. However, there is very little usable land for recreation development in this area and the project could provide little water supply or flood control. Moreover, the recreation planner considered that a reservoir development could be a detriment to the natural scenic value of Leggett Creek canyon.

Future growth of the need for recreational areas may justify a reconsideration of this site, but any proposed development should be carefully planned to preserve the natural beauty of the canyon.

Frost Damsite

This site on Redwood Creek was considered in preliminary and reconnaissance engineering evaluations before being eliminated from the study. The damsite and reservoir area were mapped in detail, and the fish and wildlife studies were carried to completion. In the course of these evaluations, several unfavorable factors were disclosed. Seismic exploration of the damsite revealed an unstable overburden of depths from 30 to 50 feet on the right abutment, and a potential landslide on the left abutment was identified. These problems, coupled with the necessity of inundating the community of Briceland, resulted in the project being dropped from the study.

Although the problems associated with this project are difficult, they are not insurmountable; the project should be reevaluated in the future when additional recreational areas and water supplies are needed within the South Fork Basin.

East Branch Basin

Five possible damsites on the East Branch of the South Fork Eel River were evaluated during the preliminary inventory. Four of these sites were rejected because of unsound geologic conditions. The fifth site, Panther, was selected for detailed study and is discussed in detail in Chapter 4.

Hilltop Damsite

This site, on the South Fork Eel River, was studied in some detail in conjunction with the San Francisco District, U. S. Army Corps of Engineers. It was found that this project had significant capabilities for flood control, recreation, and local water supply, and that the damsite was geologically sound. There are, however, several shortcomings to this site. The construction of a dam here would be very expensive due to the size of the structure involved and there is a danger of large landslides in the reservoir area. Also, the dam would have a serious detrimental effect on the anadromous fishery of the South Fork Eel River.

The Hilltop project was dropped from further study after a cursory analysis of project costs and benefits showed that the project would lack economic justification by a wide margin.

In conjunction with the study of the Hilltop site, a brief examination was made of two possible alternative sites designated as Rattlesnake and Horseshoe Bend. Both of these alternative sites were rejected because of a combination of problems concerning damsite and reservoir geology and anadromous fish.

Hollow Tree Creek Basin

The initial topographic map survey of the South Fork Basin showed five potential damsites on Hollow Tree Creek. However, the field survey showed generally that unfavorable foundation geology exists throughout the watershed and that the area is poor for recreation development due to its inaccessibility and lack of developable lands. Therefore, on

the recommendations of the recreation planner and the geologist, the five sites on Hollow Tree Creek were dropped from further consideration.

Tenmile Creek Basin

Five potential damsites were found on the initial map survey of the Tenmile Creek Basin. Field inspection of these sites revealed good foundation geology conditions and excellent recreation and water conservation potential for the projects. Cursory designs and cost estimates were prepared for all five sites. Based on the primary considerations of project costs and damsite geology, two sites, Cahto and Streeter, were found to be good. Two others, Stapp and Sebow, were fair. The Summit damsite was eliminated because of unsound geologic conditions on the right abutment that were discovered during surface geologic mapping.

From the preliminary analysis, the Cahto project was selected for detailed economic analysis. The results of this analysis are presented in Chapter 4. The Streeter project is a possible alternative that would accomplish essentially the same project purposes as the Cahto project with some reduction in water conservation and fisheries enhancement benefits.

Branscomb Damsite

Department of Water Resources Bulletin No. 92 showed that the Branscomb Project was economically justified by a narrow margin. However, a complete evaluation of the anadromous fisheries problems was not made. Due to the controversies involved with this project, it was decided that alternatives should be investigated. Therefore, the Branscomb Project was not given further consideration in this study. The Branscomb Project may merit reevaluation in the future as the need for recreation opportunities and additional water increases.

Two possible alternatives to the Branscomb Project, Taylor Creek and Standley damsites, were evaluated in this study. In comparing these two projects, the Taylor Creek site was found to be relatively expensive and to have little potential for recreation development or water conservation. The Taylor Creek site was rejected in favor of the Standley site, which is evaluated in detail in Chapter 4.

Sherwood and Long Valley Damsites

In addition to the damsites described in the preceding sections, two sites outside the South Fork Basin were initially included in this study. These two sites are Long Valley and Sherwood.

The Long Valley project was briefly evaluated as a single-purpose recreation project and found to be undesirable for this purpose. The shallow average depth of the reservoir would create an undesirable recreation environment. The preliminary evaluation of the Long Valley project did not include the possibility of supplying water to Laytonville Valley. It may be desirable in the future to reevaluate the project to meet this purpose.

Preliminary evaluation of the Sherwood project indicated that it may be desirable as a recreation project. However, it may suffer from competition from the existing Lake Mendocino or the proposed Cahto project. The limitation in time and funds on the South Fork Eel River Study made it necessary to restrict the study to the South Fork Basin and delete these two projects.

Project Formulation

The multiple-purpose concept of reservoir use was applied in analyzing potential reservoir developments. Projects were formulated to conserve water for local use, to regulate flows for downstream fishery enhancement, to provide for reservoir recreation, and to provide downstream flood protection. Due to physical locations, specific local situations, and topographic limitations, each of the projects tended to emphasize one or more of the operating criteria and to deemphasize the others. The following criteria, which were in effect in January 1967, were observed in all project planning studies conducted during this investigation:

1. The historical period 1910-11 through 1959-60 was used to evaluate water supply and reservoir water yields.

2. Downstream water users with prior rights were fully provided for in project operations.

3. Only primary tangible benefits were used in economic evaluation.

4. Project cost estimates were based on 1966 price levels.

5. All economic studies were based on a 100-year period of analysis, using an annual interest rate of 4 percent.

6. Each project was sized to produce maximum net project benefits.

Project Benefit Evaluations

To provide a basis for comparing alternatives and to determine the desirability of a given project, a monetary value must be determined for the services provided by the project. This value can then be compared with the cost of providing the services to establish the economic justification of a project.

Water Supply Benefits. The project benefits achieved through provision of new water supplies for consumptive use were considered in four categories: irrigation supplies, domestic supplies, industrial supplies, and supplies for enhancing recreation opportunities along the South Fork Eel River. The determination of benefits for water conservation was limited because specific service areas and distribution systems for water delivery could not be defined within the scope of this two-year study. Average unit costs and benefits were used to evaluate the water conservation potential of the proposed projects.

Benefits accruing to a project that provides an irrigation water supply were determined by subtracting all farm costs, except land and water costs, from the gross farm income. This gives the net return to land and water. The project benefit is the difference between the return to land and water with and without the project.

Benefits for agricultural water were computed from average values derived for each of the subunits within the study area. Average gross benefits per acre-foot of irrigation water were derived as follows: $14.00 for the Laytonville subunit, $11.20 for the Lake Benbow and Humboldt Redwoods subunits, and $18.00 for the Lower Eel subunit.

Similarly, the cost of supplying water to the farmer's headgate was derived as an average cost per acre-foot, based on rough estimates of

the pumping lifts and distribution systems required within each of the subunits. For the Lower Eel subunit, the extent of the potential service area dictated a diversion system near the upstream limits of the flat irrigable lands and an extensive system of gravity canals. With allowances for operation, maintenance, and replacement of facilities, the resulting average distribution cost per acre-foot of water within this subunit was $11.00. Within the Humboldt Redwoods and Lake Benbow subunits, service of irrigation water would be limited to those areas in close proximity to the main channel of the South Fork. The average distribution cost derived for these subunits was $6.50 per acre-foot. For the Laytonville subunit, the average distribution cost per acre-foot of agricultural water was estimated at $13.10. This high cost was due to the necessity of pumping water about 150 feet in elevation from the Cahto project, and the extensive distribution canal system to serve the elongated Laytonville Valley. Since an alternative supply of water is available to this area in the essentially undeveloped ground water basin, the demand for agricultural water in the Laytonville subunit was excluded from the estimated demand for project yield.

Benefits accruing to a project that provides a domestic water supply were computed by determining the amount a beneficiary would be willing to pay for project water. In this study, the value of an acre-foot of water delivered to the treatment plant intake was used as a gross benefit. For the three subunits comprising the South Fork Eel River Basin, a gross benefit for urban water of $96 per acre-foot was computed, using the current water rate in the community of Laytonville as a base. For the Lower Eel subunit, the computed gross benefit was $68 per acre-foot, based on the current water rate in the community of Hydesville.

The estimated cost of delivering domestic water to the treatment plant intake was based on the assumption that conserved water would be diverted from the stream channel at the area of use. Thus, the stream channel would serve as the main distribution canal and the cost of supplying water for domestic use would consist primarily of pumping costs and the cost of the diversion structure. For the three subunits in the South Fork Eel River Basin, this diversion cost was estimated at $15.50 per acre-foot. For the Lower Eel subunit, the diversion cost for domestic water was estimated at $11 per acre-foot.

As discussed in Chapter 2, provision of an industrial water supply was evaluated on the basis of an expansion of the pulp and paper industry in the Lower Eel subunit. Assuming that a single diversion would be made to one pulp and paper plant and that this plant would use the entire industrial yield, the cost of delivering this yield to a plant in the Lower Eel subunit was estimated at $6.50 per acre-foot. The benefits for providing this industrial supply were estimated to be $20 per acre-foot of water delivered to the plant intake, based on present water costs for similar industries.

Since there are no criteria available for evaluating the benefits associated with supplying water for recreational purposes, it was assumed for the South Fork study that these benefits would be similar to the benefits for supplying water for domestic use. As previously described, a gross benefit of $96 per acre-foot was determined for the South Fork Basin and a gross benefit of $68 was determined for the Lower Eel subunit. The estimated diversion costs for domestic water of $15.50 and $11 were also used in evaluating the conservation of water for recreational purposes.

Flood Control Benefits. One of the major considerations in formulating projects within the South Fork Eel River Basin was flood protection. The flood problem of the North Coastal area received nationwide publicity due to the devastating floods of 1955 and 1964. Rampaging streams throughout the area set records of peak stage and runoff in December 1955, then rose again in December 1964 to break those records. The records of the stream gaging station near Miranda show that the South Fork Eel River rose 42.7 feet in 1955, reaching a peak discharge of 173,000 second-feet, and in 1964 rose 46 feet, reaching a peak discharge of 199,000 second-feet. The unparalleled flood of 1964 devastated Myers Flat and Weott in the lower South Fork Basin, completely disrupted transportation and communication facilities, and took a heavy toll in lives and property.

The San Francisco District of the U. S. Army Corps of Engineers prepared a reconnaissance evaluation of the flood control capabilities of selected South Fork Eel projects in 1966. This work was accomplished under a joint interagency program of coordinated planning for the development of the water resources of the Eel and Mad River Basins, administered by the California State-Federal Interagency Group.

Preliminary flood stage evaluations by the Corps of Engineers showed that reservoir storage on tributaries to the South Fork Eel River would have little effect on major floods. The Corps' studies for the proposed Hilltop project on the South Fork Eel River at Leggett indicated that 250,000 acre-feet of flood control storage at that site would lower the December 1964 flood peak at the Miranda gaging station by only 8 feet while the flood peak was 19 feet above the damage level.

The major portion of the damages within the South Fork Basin occur along the main channel of the South Fork Eel River downstream from Benbow Dam. To prevent these damages, flood control reservoirs would have to control the runoff from a major portion of the South Fork Basin. From a comparison of reservoir drainage areas and storages with the total drainage area and flood runoff volume for the South Fork Basin, it was obvious that the projects under study would have an almost unmeasurable effect on major floods, such as occurred in 1955 and 1964. However, the Corps' studies showed that a significant portion of the potential flood control benefits could be obtained by controlling the smaller, more frequent floods.

Evaluation of the flood control potential of the projects under study was based on a comparison of estimated benefits provided by the Corps with the cost of providing flood control storage. The benefit-cost comparison for each of the projects is presented in the discussion of individual projects in Chapter 4. In most instances, it was found that the cost of providing flood control storage exceeded the benefits that could be obtained. A flood control reservation was found to be justified at only one project, the Cahto project on Tenmile Creek.

Since reservoir storage at the proposed projects cannot provide control of major floods, a comprehensive program of floodplain management will be necessary within the South Fork Basin. It may be best for the basin to rely completely on floodplain management to prevent flood damages and operate the proposed projects primarily for recreation and water conservation. Flood control operation requires that flood control storage reservations be maintained until April 1 of each year, which would prevent the capturing of a major portion of the heavy winter runoff in January and February. This mode of operation is in direct conflict with

the purposes of recreation and water conservation. In the interest of these purposes, the reservoir should be operated to store as much of the winter runoff as possible, thus providing a larger pool for summer recreation use and conserving the maximum amount of water for use in the summer months of short supply.

The small communities along the lower South Fork that suffer repeated flood damage are obviously in the floodplain and should consider the possibility of relocation. In 1966 the Department of Parks and Recreation initiated a study of possible land exchanges whereby the affected communities could be relocated and the State could obtain floodplain lands that would be ideally suited for recreational use. This land exchange study has not been completed. Communities interested in this concept may wish to explore the possibilities with the Department of Parks and Recreation.

Development of recreation areas in the floodplain could complement the scenic attraction of the redwood parks by providing a greater variety of recreational uses, including picnic areas and swimming beaches. These developments could be made more attractive to recreation users by incorporating low dams on the South Fork Eel River to impound small recreation reservoirs (see the discussion of low dams at the end of Chapter 4).

Recreation Benefits. Recreation has had and will continue to have a dominant influence on the economy of the North Coastal area. The South Fork Eel River Basin, encompassing some of the most famous of California's State Parks, will be a major recipient of the increase in demand for outdoor recreation opportunities.

As a part of the South Fork Eel River Study, the Department of Parks and Recreation prepared a preliminary evaluation of the present and estimated future demand for recreation use within the study area. This evaluation included projections of the recreation use that would occur at the projects under consideration. The report on this recreation study is included in this bulletin as Appendix B.

Recreation use at the proposed projects was estimated on the basis of the available land, the accessibility of the project, the estimated user demand for project facilities, and the assumption that Department of Parks and Recreation Type "A" standard facilities would be constructed.

In March 1966, the Department of Water Resources adopted standards for recreation evaluation similar to the federal standards set forth in Senate Document No. 97, Addendum No. 1. The Department, in cooperation with the Departments of Fish and Game and Parks and Recreation, has developed guidelines for applying the general standards. These guidelines were used in evaluating recreation benefits within the South Fork Eel River Study.

Recreation activities have been divided into two classes, general and specialized. General recreation, including such activities as boating, swimming, camping, and picnicking, was evaluated as described below. The evaluation of benefits for specialized recreation use, which is concerned primarily with utilization of fishery and wildlife resources, is described in the following section on fish and wildlife. Reservoir trout fishing is evaluated as part of the general reservoir recreation, and the benefits for this use are deducted from the general recreation and credited to fisheries enhancement.

The monetary benefit value associated with a general recreation visitor-day is determined on the basis of the variety and quality of recreation experiences available at the reservoir, the quality of facilities provided, the esthetic surroundings of the reservoir, and the degree to which the water surface fluctuates during the recreation season. Using a point system set forth in the interim guidelines for evaluating general recreation, the projects under study were rated on the first three of these qualities. The applicable value for water surface fluctuation was determined from reservoir operation studies. The ratings thus established determined the visitor-day value for general recreation within the established range of 50¢ to $2.50. Unit benefits determined for individual South Fork projects ranged from $1.75 to $2.26.

Fish and Wildlife Benefits. The South Fork Eel River supports sizable runs of king salmon, silver salmon, and steelhead trout. These three species of anadromous fish support the major fishery of the river. The two species of salmon also contribute to both the ocean sport and commercial fishery.

A major effort within the South Fork Eel River Study was centered on fish and wildlife evaluations. These evaluations were made by the Department of Fish and Game. Their report is bound within this bulletin as Appendix C. One of the recommendations in Bulletin No. 92, "Branscomb Project Investigation", was that a basinwide study of the South Fork include a comprehensive evaluation of the fish and wildlife resources. However, the limited scope and funds of the study program reported herein restricted the fish and wildlife evaluations to the specific projects under study.

In the survey of reservoir sites during the South Fork Eel River Study it was found that little or no wildlife enhancement could be provided by the projects, but that significant fisheries enhancement could be provided by several of the projects. The potential fisheries enhancement was evaluated in four parts: reservoir fisheries, downstream nursery enhancement, early entry to spawning areas, and increased spawning areas.

The benefits for reservoir fisheries were evaluated as part of the general reservoir recreation using the values previously described. The portion of the general recreation use at the project attributable to reservoir fishery is evaluated separately as a fishery benefit and is presented as such in Chapter 4.

As described in Appendix C, summer releases of cool water from the proposed reservoirs would enhance nursery habitat for juvenile steelhead, silver salmon, and trout downstream from the projects. The increase in fish populations sustained by these summer releases was estimated by the Department of Fish and Game and are shown in Table 8 of Appendix C. The fisheries benefits attributable to each project were computed by multiplying the increase in numbers of fish caught, both commercially and by sport fishermen, by the estimated net value of the fish. The value of the fish was determined by a combination of two factors, a commercial value of 34¢ per pound and the specialized recreation value of sport fishing.

Regulated flow releases from the proposed projects could also provide additional spawning area for king salmon, especially during dry years. The increase in fish population that could be induced by various releases is shown in Table 9 of Appendix C. The economic evaluation of

the benefits associated with the increased populations of king salmon are evaluated in the same manner as described previously for the enhancement of nursery areas.

The Department of Fish and Game has estimated that a sustained streamflow of suitable temperature in the South Fork Eel River of 150 cfs or more would allow king salmon to migrate into the South Fork. Under present conditions, these fish are usually unable to migrate upstream from the Eel River estuary prior to the first major rainfall. As described in Appendix C, the major economic benefit from this early migration would result from a substantial increase in the river sport fishery for salmon and steelhead. An estimate of the increased angler use in the South Fork Basin is shown graphically in Figure 5. The benefits associated with this increase in use were determined by the specialized recreation value of the added angler-days of river sport fishing.

There are several factors in the evaluation of fishery enhancement that might preclude realizing the benefits described. The Department of Fish and Game mentions two items, water temperature and early entry, that still need extensive study.

For the evaluations in this study, it was assumed that water released from the proposed reservoirs would be of appropriate temperature for anadromous fish. Preliminary temperature studies by fishery biologists

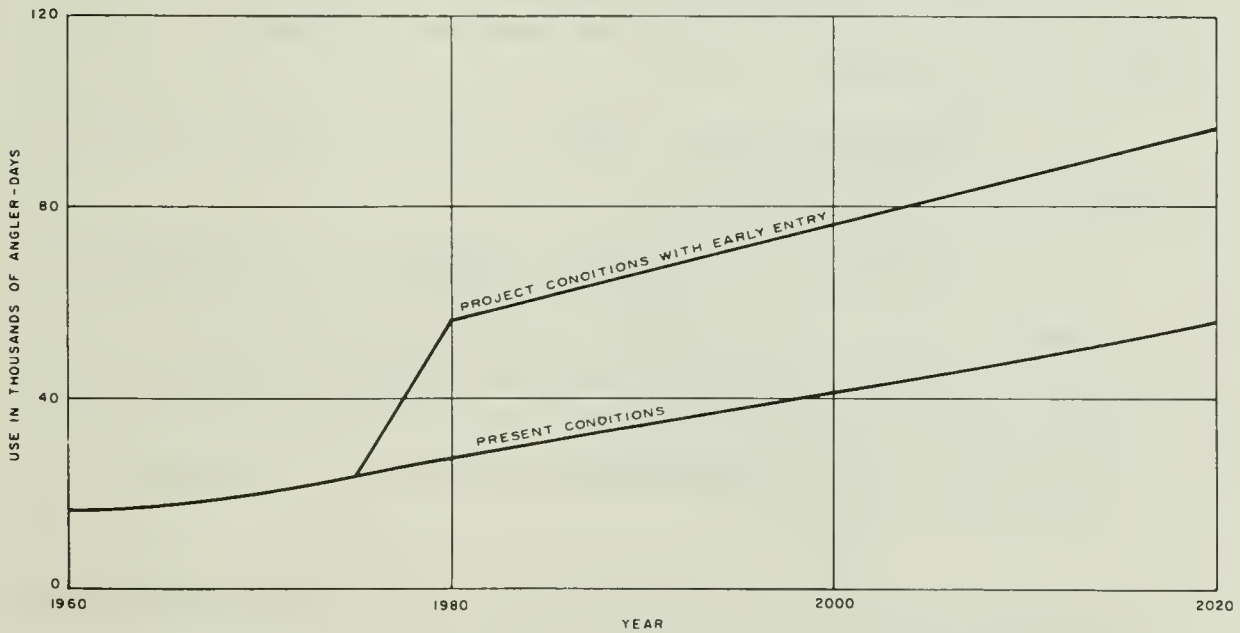


Figure 5. ESTIMATED INCREASE IN RIVER SPORT FISHERY FOR SALMON AND STEELHEAD

indicate that the volumes of cool water in the reservoirs should be adequate in most years. However, maintaining a flood control reservation or making large releases during the summer may overdraw the supply of cool water and may prevent not only fisheries enhancement but also possibly the maintenance of the existing fish population in the area affected by the reservoir.

The possibility of inducing an early migration of fish into the South Fork was first proposed in the Branscomb Project Investigation. The requirements for inducing this migration, in terms of water quantities and temperature, are not known. Also, the effect of the corresponding increase in fishing pressure on the fish population is subject to some doubt. On the basis of present information, it was assumed that the early migration could be induced and that angling use would increase.

Further study is needed on both of the foregoing items before an accurate estimate of the overall effect on anadromous fish can be made. The Department of Fish and Game has recommended that a temperature study be made before more advanced studies are begun on any proposed project.

Reservoir Operation Studies

The general criteria for operation of proposed reservoirs varied according to the characteristics of the project being considered. Reservoirs were operated to provide for local irrigation, urban, and recreation water requirements; to regulate flows to provide for downstream fishery enhancement; to develop reservoir recreation; and to provide flood control.

In determining yields to meet local water requirements, the following assumptions were made:

1. The demand for irrigation water would be limited to the amount that could be delivered at a cost within the average payment capacity of crops projected within the study area.

2. Present and pre-project water requirements would continue to be met from existing sources.

3. The project demand buildup period would be as shown in Table 12 in Chapter 2.

Table 14 gives the monthly distribution of local water demand used in operating reservoirs for new yield.

TABLE 14
ESTIMATED MONTHLY DISTRIBUTION OF WATER DEMAND
IN PERCENT OF SEASONAL TOTAL

Month	Recreation	Irrigation		Urban	Industrial
		South Fork Basin	South Fork Basin & Lower Eel Subunit		
January	1	0	0	6	8
February	1	0	0	6	7
March	1	0	0	7	9
April	1	0	0	7	8
May	1	7	8	8	9
June	20	19	20	10	8
July	22	32	30	12	9
August	22	28	26	12	9
September	18	14	16	10	8
October	10	0	0	8	9
November	2	0	0	7	8
December	1	0	0	7	8

In operating the proposed reservoirs, it was assumed that the channel of the South Fork Eel River would serve as the main distribution conduit for water conserved for urban, recreational, or agricultural use. Water released from storage would thus provide streamflow enhancement for fisheries and recreation down to the point where it is diverted from the stream channel for use.

The Department of Fish and Game has estimated streamflow maintenance and enhancement requirements below each of the project reservoirs. The maintenance requirements were incorporated into all operation studies conducted for this investigation. These fish maintenance flows were determined to be required in the tributary streams below proposed projects only to the point where tributary streams enter the main stem of the South Fork. Thus, water releases required for fish maintenance can be used for other purposes in the lower basin.

Reservoir storage sufficient to insure protection of reservoir fishlife was maintained at each reservoir. In addition, wherever feasible, maximum reservoir levels were maintained through the summer recreation seasons.

Topographic Mapping

Large-scale topographic maps were prepared for the following damsites: Panther, on the East Branch of the South Fork; Frost, on

Redwood Creek; Standley, on the upper South Fork; and the five sites on Tenmile Creek. The Panther and Frost damsites were mapped at a scale of 1" = 400' with a contour interval of 20', using control elevations set by the Department. The Standley project and the five Tenmile Creek projects were mapped at a scale of 1" = 600' with a contour interval of 20', using aerial photographs and control elevations obtained from the U. S. Geological Survey.

This large-scale mapping was used in the preparation of designs and cost estimates for the projects, for field mapping of damsite and reservoir geology, for computation of reservoir capacities and surface areas, to determine potential recreation areas, and to lay out necessary road relocations.

Geologic Investigations

Evaluation of geologic factors is essential in the preparation of plans, designs, and cost estimates for physical features of water development projects. Geologic investigations for the South Fork included (1) study of geologic formations with particular emphasis on the sites of proposed structures, (2) surface geologic mapping of dam and reservoir sites, (3) collection of soil samples to determine the properties of available materials, and (4) determination of quantities of available materials. In studying the sites, emphasis was placed on the determination of rock types, degree of weathering, patterns of jointing, the nature and extent of shear zones, and other engineering properties of foundation materials.

Geologic studies for this investigation varied from preliminary reconnaissance of surficial geologic features at some sites to subsurface exploration at other sites. The geologic conditions encountered at those sites considered likely for near-future construction are described in Chapter 4. Results of all of the geologic studies conducted for this investigation were recorded in an office report, "Engineering Geology of Damsites, South Fork Eel River Study", which is available in the files of the Northern District, Department of Water Resources, in Red Bluff.

Designs and Cost Estimates

The preparation of realistic designs and cost estimates is of vital importance in the economic evaluation of water development projects. All cost estimates prepared during this investigation include allowances for costs of engineering, administration, contingencies, and interest during construction. Annual costs were computed for a 100-year period of analysis and a 4 percent interest rate with an appropriate allowance added for operation, maintenance, and replacement.

Preliminary designs and cost estimates, based on 1966 price levels, were prepared for those projects considered likely for near-future construction. These estimates were reviewed by the Department's Division of Design and Construction and are on file in the Northern District office in an office report, "South Fork Eel River Study - Designs and Cost Estimates".

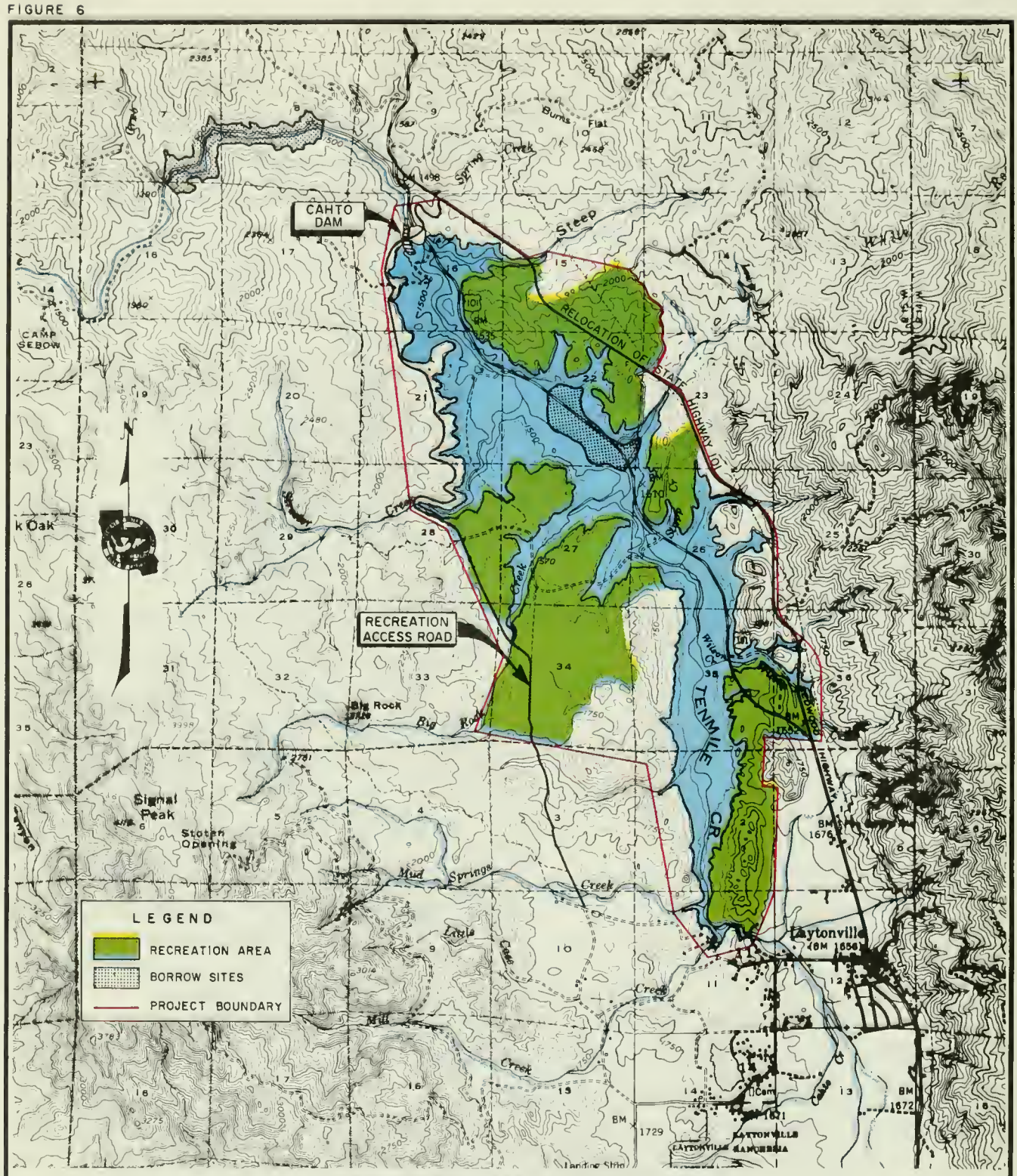
The cost of property to be acquired can be of major consequence in preparing cost estimates for water projects. Property appraisals, including land values, improvements, and severance costs, were prepared for all of the South Fork projects. Memorandum reports on each of the three projects discussed in Chapter 4 are on file in the Northern District office.

Economic Justification

The economic justification of projects under study was determined by comparing the total capitalized value of primary project benefits with the total project cost. This comparison was made on a present worth basis using a 100-year period of analysis and a 4 percent interest rate, with an assumed project construction date of 1975. Proper inclusions were made for the value of future additions to the projects and for operating and maintaining the projects.

The comparison of project benefits and costs is normally made in the form of a fraction designated the benefit-cost ratio. A project is considered to be economically justified if its primary benefits exceed its costs; in other words, if its benefit-cost ratio exceeds unity.

FIGURE 6



NORTH COASTAL AREA INVESTIGATION
SOUTH FORK EEL RIVER STUDY

CAHTO DAM
AND
RESERVOIR

SCALE OF MILES
0 1/2 1 2

CHAPTER 4. PLANS FOR WATER DEVELOPMENT

Through the inventory and inspection of damsites described in the previous chapter, the field of study for this investigation was narrowed to three potential projects, Cahto, Panther, and Standley. These three projects were evaluated in detail to determine the services they could provide and the benefits which could be realized from those services. This chapter describes the physical features, operational criteria, and accomplishments of these projects and summarizes the economic evaluation of project costs and benefits. It also includes a discussion of low dams for recreation purposes.

The Cahto Project

The Cahto Project (Figure 6) would be located on Tenmile Creek at the north end of Laytonville Valley, about six miles north of Laytonville. A 163-foot zoned earthfill dam at this site would impound a reservoir of 95,500 acre-feet of water, covering 1,760 acres at a normal water surface elevation of 1,580 feet. Headwaters of the reservoir would be about one mile west of Laytonville. Much of the land bordering the 36-mile shoreline of the reservoir is relatively flat meadow, ideally suited for recreation development. These developable lands, together with the ready access from Highway 101, make water-associated recreation the predominant accomplishment of the Cahto Project.

Hydrology

The drainage area at Cahto damsite is 50.3 square miles and the mean annual runoff is 91,400 acre-feet, yielding an annual runoff-area ratio of approximately 1,800 acre-feet per square mile. Runoff estimates were derived from the records of the stream gaging station "Tenmile Creek near Laytonville", which is located just upstream from Cahto damsite. (See Table 9 in Chapter 2.)

A probable maximum flood with a peak discharge of 35,500 cfs and a standard project flood hydrograph with a peak discharge of 24,000 cfs were computed for Cahto damsite. These flood peaks were used in the design

of diversion works and the spillway for the project. The largest recorded flow at the gaging station was 14,500 cfs in December 1964.

Geology

Foundation exploration at Cahto damsite was limited to surface geologic mapping and a seismic refraction survey. The results of these studies are presented in an office report, "Engineering Geology of Damsites, South Fork Eel River Study", which is on file in the Northern District office. The geology of Cahto damsite is shown in Figure 7.

The Cahto damsite and reservoir area are underlain by rocks of the Franciscan Formation. Rock types include sandstone, shale, greenstone, chert, and a variety of metamorphics consisting principally of blue schist. Sandstone is the dominant rock type at the damsite and throughout the reservoir area.

Heavy overburden in portions of the Tenmile Creek Channel and on the adjacent slopes obscures most of the bedrock, making identification of the geologic structures at the site difficult without drilling or trenching. However, it was determined that extensive shearing has occurred adjacent to the damsite, with one of the larger shear zones passing through the area just above the right abutment. Due to the combination of shearing, faulting, and jointing, the bedrock at the site varies from moderately to very blocky and seamy. In spite of the large amount of fracturing many of the fractures are tight and in some instances appear partly healed.

Small slides exist on both sides of the channel immediately upstream and downstream from the proposed damsite. Removal or stabilization of portions of these slides above the embankment or spillway will be necessary. Foundation preparation would include the removal of slope wash deposits, terrace deposits, local slides, and stream gravels.

In conclusion, the reconnaissance-level geologic investigation indicated that: (1) the site appears suitable for a 163-foot earthfill dam, (2) the left abutment appears suitable for a spillway site, (3) there are no known active faults at the site, (4) the foundation appears to be impervious, but because of fracturing a grout curtain should be installed, and (5) drilling and trenching will be necessary at the site to accurately

determine the position of shear zones and to more accurately determine the suitability of the foundation for construction of a dam at this location.

Construction Materials

Impervious and pervious borrow materials are present within or near the reservoir area. The haul distances are reasonable and generally good access exists. An estimated 2,000,000 cubic yards of impervious material are located in the proposed reservoir within two miles of the damsite. Approximately 1,000,000 cubic yards of pervious streambed gravels are located in Tenmile Creek within three miles of the damsite. Rock from the spillway site on the left abutment appears to be suitable for rockfill and riprap. The locations of proposed material borrow areas are shown in Figure 6.

Cahto Dam would require 884,000 cubic yards of fill material, of which 213,000 cubic yards would be impervious core, 477,000 cubic yards would be pervious shell, and 194,000 cubic yards would be rockfill and riprap.

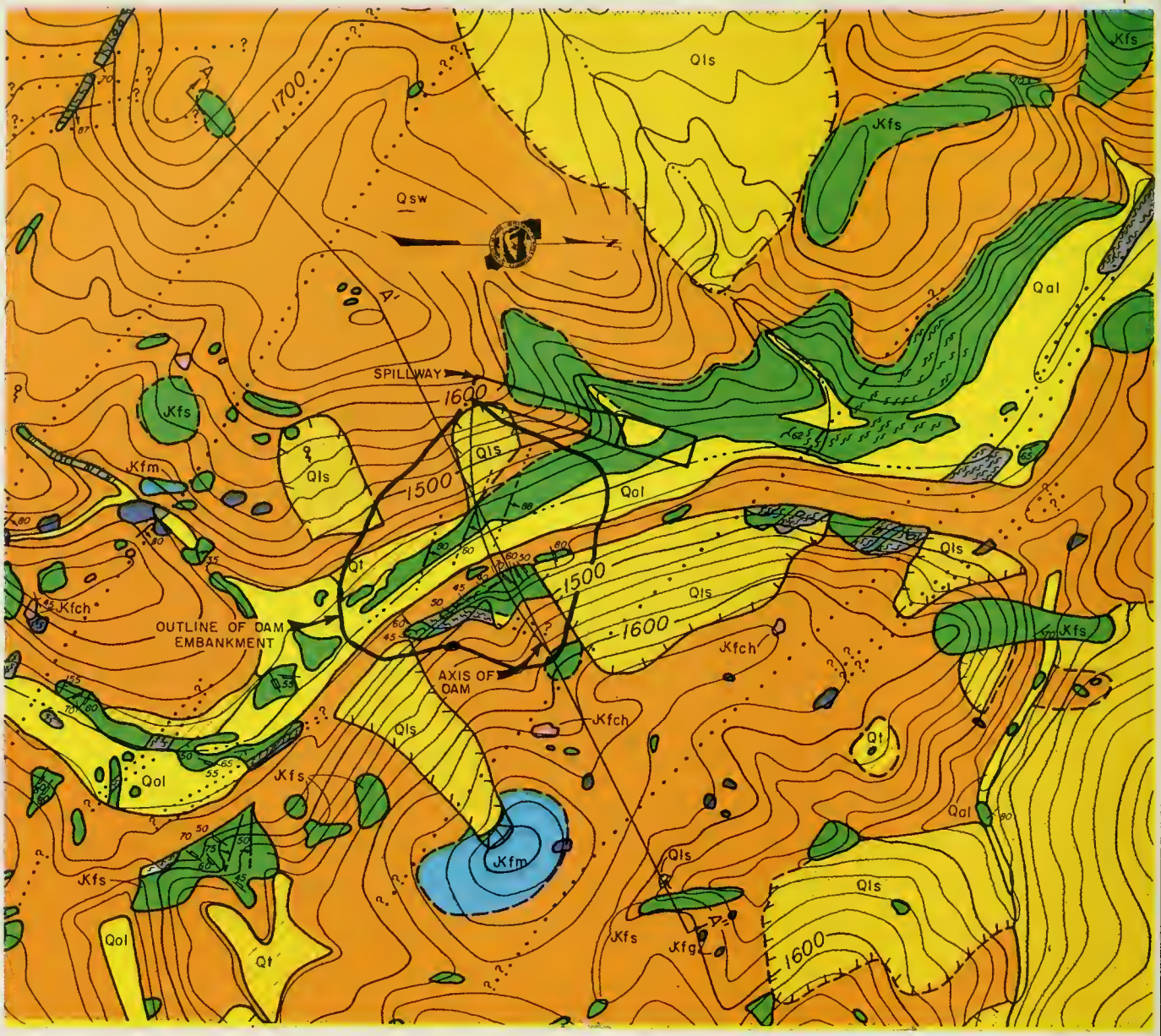
The Department of Parks and Recreation has suggested that, during the processing of stream gravels for the drain zone of the dam, excess material of the appropriate size be stockpiled for constructing swimming beaches in the recreation areas. The mining of stream gravels should be properly planned to avoid the destruction of spawning areas for anadromous fish.

Project Features - Designs and Costs

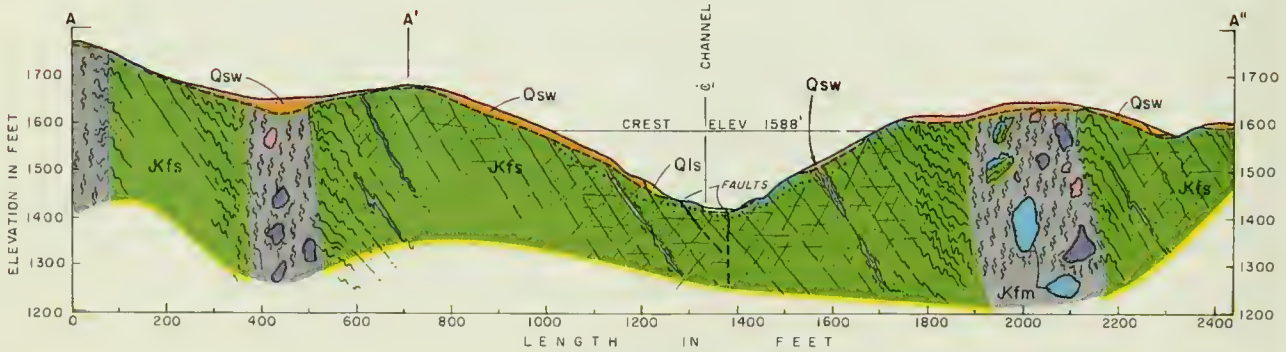
The Cahto Project as proposed would consist of the following features: (1) dam and appurtenant structures, (2) reservoir, (3) recreation facilities, and (4) Highway 101 relocation around the reservoir. General project features are shown in Figure 7 and described in detail in the following sections.

Cahto Dam. The dam would be a zoned gravelfill embankment 163 feet high with the crest at elevation 1,588 feet. The section would consist of an impervious core zone supported by shells of select stream gravels. Rock quarried from the spillway and approach channel would be

CAHTO PROJECT GEOLOGIC PLAN AND SECTION

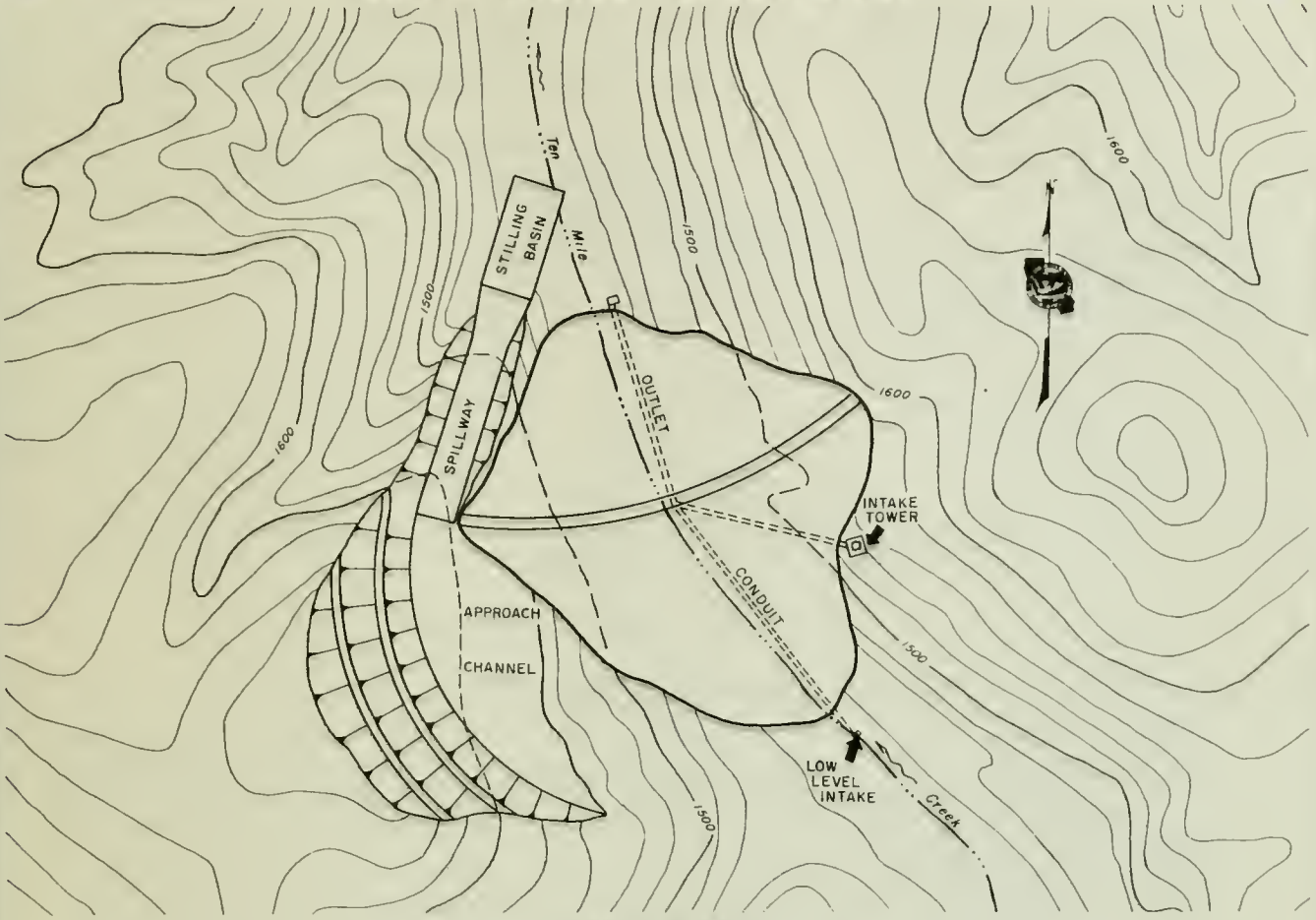


SCALE OF FEET
200 0 200 400
CONTOUR INTERVAL 20'



SECTION A-A'-A"

CAHTO PROJECT GENERAL PLAN



LEGEND

Qal — **STREAM DEPOSITS**
Franciscan gravels, sands and silts.

Qsw — **SLOPE WASH**
Widespread and locally deep cover of rocky soil derived from Franciscan bedrock.

Qls — **LANDSLIDES AND SLUMPS**
Landslides and slumps of various sizes and depths.

Qt — **TERRACE DEPOSITS**
Discontinuous, thin bodies of gravels and sands.

Jkfs — **SANDSTONE**
Graywacke sandstone with minor amounts of shale. Sandstone fractured, and shale usually sheared.

Jkfg — **GREENSTONE**
Hard, moderately fractured rock; isolated exposures of various sizes.

Jkfch — **CHERT**
Hard, brittle, crumpled rock; isolated exposures of various sizes.

Jkfm — **METAMORPHICS**
Consists principally of hard, fine groined, frogmental blue schist. Other metamorphics include schists of various types.

SYMBOLS

40 — Attitude of bedding

25 — Attitude of crumpled beds

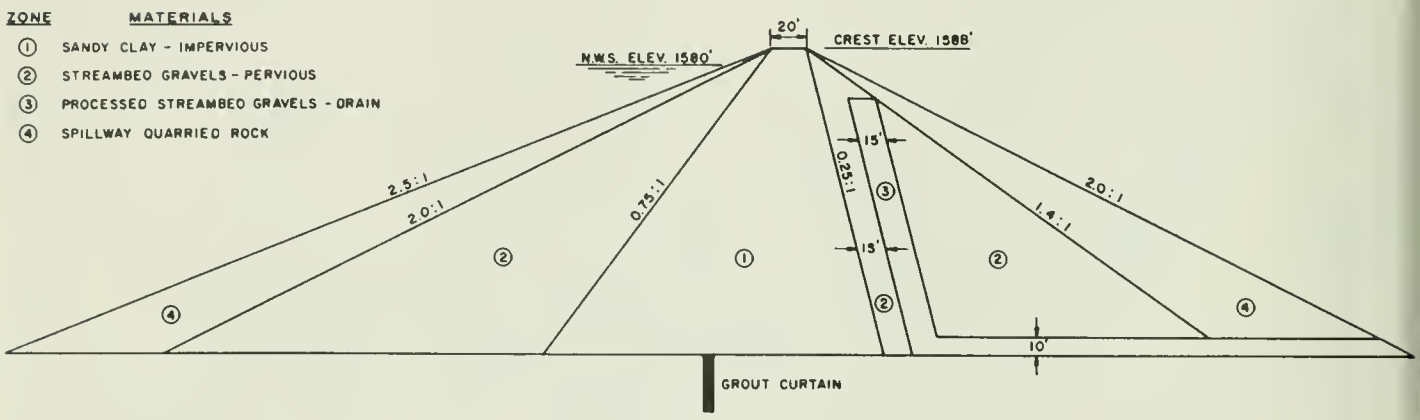
60 — Attitude of jointing

Geologic contact - dashed where approximately located and dotted where concealed.

Fault showing dip of fault plane. Dashed where approximately located.

Shear zone. Dotted where projected beneath cover. Question marks indicate further projections may not be reliable.

used on the exterior faces of the dam to provide slope protection and add to the stability of the section under rapid drawdown conditions.



CAHTO DAM - MAXIMUM SECTION

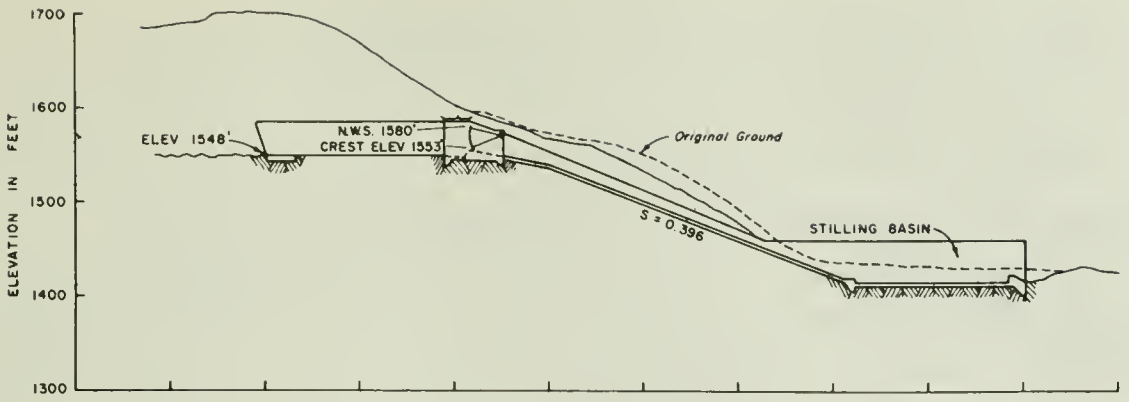
SCALE OF FEET
50 0 50 100

Foundation preparation would consist of stripping to solid material and grouting.

Spillway. A concrete-lined chute spillway would be located on the left dam abutment. Discharge would be controlled by an ogee weir at elevation 1,553 feet topped by two 28' by 28' radial gates. The spillway was designed to pass the probable maximum flood (35,500 cfs) with a maximum pool elevation of 1,585 feet. The maximum flood of record (14,500 cfs in December 1964) could pass through the spillway with the reservoir water surface at about elevation 1,571 feet. To insure the safety of the dam, the radial gates would be constructed with a mechanism that would force the gates open in relation to the rise in water surface above the elevation of the top of the closed gates. This device would be independent of external power sources and human attendance.

The 400-foot-long by 60-foot-wide concrete chute would be founded on a ridge of sound graywacke sandstone extending down the left abutment. The chute would discharge into a 180-foot stilling basin.

A total of 261,000 cubic yards of soil and rock would be excavated for the spillway. Of this, about 185,000 cubic yards of yards of rock could be used in Zone 4 of the dam.



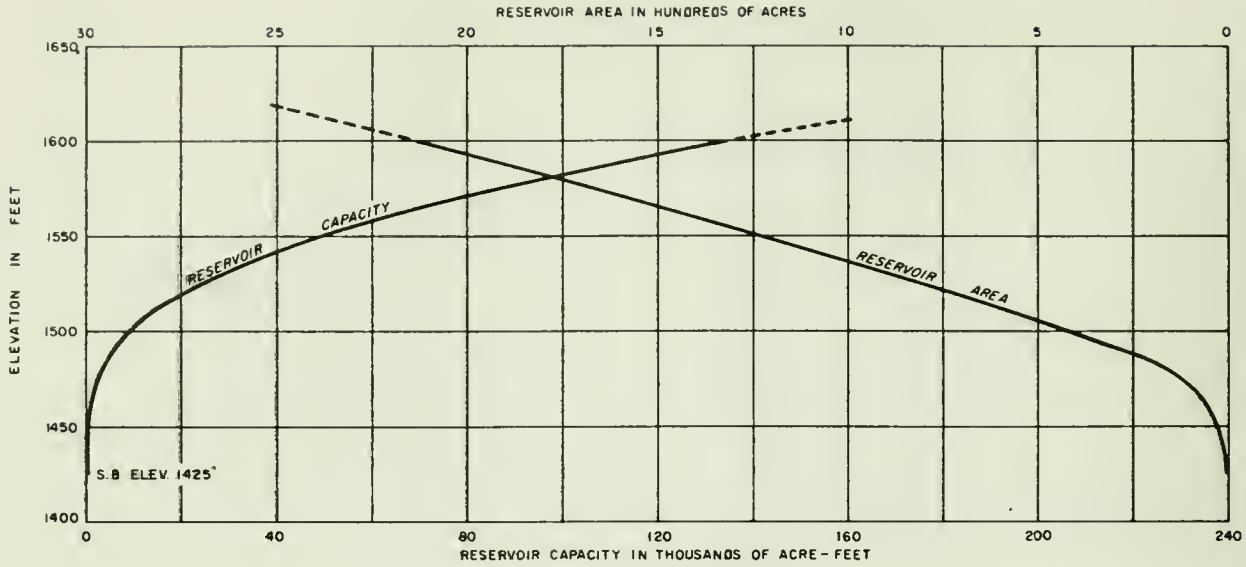
CAHTO DAM
PROFILE OF SPILLWAY
SCALE OF FEET
100 0 100 200 300

Outlet Works. A 68-foot-high vertical, multiple-level intake tower would be located on the right abutment. Flow into the intake would be regulated by three 45-inch butterfly valves. A low-level intake would be positioned at the upstream end of a cut-and-cover diversion conduit in the existing stream channel. The tower, in conjunction with the low-level outlet, would allow releases at various levels to control the temperature of water withdrawn from the reservoir.

Cahto Reservoir. The reservoir would have a gross storage capacity of 95,500 acre-feet at a normal water surface elevation of 1,580 feet, covering an area of 1,760 acres. Approximately 4,850 acres of land would have to be acquired for the reservoir and recreation development areas. Reservoir capacity and water surface area at various water surface elevations are shown in the following graph.

The basic project cost for land acquisition was determined from the minimum amount of land necessary to construct and operate the project. This area would be the maximum water surface area plus a strip of land 300 feet wide around the shoreline, or about 3,700 acres altogether. The cost of additional areas required for recreation development is included with the recreation facilities cost.

The reservoir would require clearing between the normal water elevation of 1,580 feet and the minimum water elevation of 1,520 feet,



CAHTO RESERVOIR
AREA-CAPACITY CURVES

an area of about 1,000 acres. An access road would be constructed around the west side of the reservoir to provide access to the potential recreation areas on the west shore.

Highway 101 Relocation. Cahto Reservoir would inundate about five miles of Highway 101. Relocation of the highway would require construction of 5.8 miles of roadway around the east side of the reservoir.

The Division of Highways District I Office in Eureka is currently making preliminary route studies to improve to freeway standards most of the stretch of roadway that would be inundated. The scheduled construction date of this improvement is about 1975.

In discussions with the Division of Highways concerning the necessary relocation, it was agreed that the appropriate cost to the proposed Cahto Project would be the difference between the cost of improving the present two-lane roadway to freeway standards and the cost of constructing a freeway around the reservoir. Using reconnaissance unit costs provided by District I, the corresponding costs were estimated as:

1.	Freeway around reservoir	$8,700,000
2.	Present roadway to freeway	$5,700,000
3.	Project cost (difference)	$3,000,000

The above cost is only an approximation; a more refined cost estimate would require a detailed route study by the Division of Highways.

Delaying the construction of the Cahto Project until after the highway improvement is completed would require that the project then bear the entire cost of constructing a freeway around the reservoir area. Such delay would increase the capital cost of the project by about $5,700,000.

Recreation Facilities. The cost of recreation facilities for the Cahto Project was determined by the Department of Parks and Recreation. These facilities would be constructed in five areas (see Figure 6) comprising about 1,150 acres. Installation of facilities would be staged in accordance with the predicted recreation use of Cahto Reservoir as presented in Appendix B. Initial facilities would accommodate about 538,000 visitor-days per year. Additional facilities would be built as needed, up to the maximum use capacity of about 3,750,000 visitor-days by the end of the period of analysis.

In addition to the facilities costs developed in Appendix B, the initial capital cost of recreation development would include the costs of additional lands for recreation use and access roads.

Fish and Wildlife Preservation. The cost of facilities to maintain the fish and wildlife populations in the reservoir area were determined by the Department of Fish and Game. Estimates of the required facilities and costs are presented in Appendix C. These facilities include the development of deer range for mitigation purposes and the construction of a fish hatchery below Cahto Dam. The construction of a multiple-level outlet structure to provide temperature control of releases from the reservoir is also included in the cost of fish and wildlife preservation.

These costs are not considered separable costs for fish and wildlife in allocating project costs, since the preservation of these resources is a project obligation.

Flood Control. The flood control capability of the Cahto Project is very limited due to the small percentage of the basin runoff that could be controlled. The 50.3-square-mile drainage area comprises only 7.3 percent of the South Fork Eel River Basin. Hence, the effect on major floods of a flood control reservation in Cahto Reservoir would be almost unmeasurable in the lower South Fork Eel River Basin.

A reconnaissance study by the U. S. Corps of Engineers determined the flood storage requirements and corresponding annual benefits for the Cahto Project. The cost of providing a flood reservation was determined as the incremental dam and reservoir cost to provide the required additional storage. Flood control releases up to 30,000 acre-feet could be made through the gated spillway, hence no large outlet works would be required for smaller reservations. To prevent encroaching on the community of Laytonville, the maximum water surface elevation was limited to 1,585 feet. The following tabulation presents the estimated costs and benefits for various flood control reservations.

Flood Control Storage	Capitalized Benefits	Capital Cost of Providing Storage
28,000 acre-feet	$2,820,000	$1,370,000
41,000 acre-feet	$3,310,000	$2,640,000
65,000 acre-feet	$3,430,000	$4,110,000

These figures indicate that providing up to about 50,000 acre-feet of flood control storage would be justified. However, this would seriously infringe on the water conservation and recreation aspects of the project. Operation studies showed that a flood reservation of about 20,000 acre-feet would be compatible with other project purposes. A preliminary cost allocation, assigning a portion of the remaining joint costs to the purpose of flood control, showed that a reservation of 20,000 acre-feet would be justified. Therefore, this amount of flood control storage was included in the project formulation. Extrapolation of the costs tabulated above indicated that the cost of providing 20,000 acre-feet of storage would be about $1,000,000. This amount of flood storage would control only the smaller, more frequent floods. The effect on major floods such as occurred in 1955 and 1964 would be insignificant.

Water Conservation. Project costs for water conservation are normally determined by defining specific areas and making cost estimates of facilities to deliver water to the service areas. In this study, an approximate unit cost was developed for various water uses and applied to the conservation yield of the project. From the projected demand for

water discussed in Chapter 2 and the unit costs shown in Chapter 3, the capital cost to divert and pump the 18,000 acre-feet of conservation yield from the Cahto Project was estimated to be about $3,800,000. Approximately $400,000 of this amount would be the initial capital cost with the balance coming as future expenditures.

Summary of Costs. A summary of the estimated project costs during the 100-year period of analysis is presented in Table 15. The initial capital outlay for this project is estimated to be $15,100,000. The present worth of the total expenditure during the period of analysis is estimated to be $37,700,000.

TABLE 15

SUMMARY OF CAHTO PROJECT COSTS

Project Feature	Capital Cost	Operations, Maintenance, Replacement, and General Expense*	Present Worth of Total Expenditure Over 100 Years
Cahto Dam, Reservoir, and Appurtenances	$ 7,400,000	$ 1,000,000	$ 8,400,000
Recreation Facilities	3,900,000	17,400,000	21,300,000
Fish and Wildlife Preservation	400,000	800,000	1,200,000
Highway 101 Relocation	3,000,000	0	3,000,000
Water Conservation - Diversion and Pumping	400,000	3,400,000	3,800,000
TOTAL	$15,100,000	$22,600,000	$37,700,000

* Includes present worth of all future additions and expenditures.

Project Accomplishments and Benefits

The formulation of the Cahto Project included the purposes of local water supply, flood control, recreation, and fish and wildlife enhancement. In the analysis of this project, a number of operation studies were made to define project yields and compare alternative sizes. The optimum scale of development would be near the size presented here. However, a more advanced study, including a refined analysis of water service areas and associated benefits, would be necessary to confirm the size of the project.

TABLE 16

SUMMARY OF MONTHLY OPERATION STUDIES
OF CANTO RESERVOIR

95,500 Acre-Feet of Storage
(In 1,000 Acre-Feet)

Runoff Year	Storage on October 1	Inflow	Annual Water Releases and Losses				
			Fishery Maintenance[1]	Recreation, Urban and Agricultural Yield[1]	Evaporation	Spill	Total
1911-12	64.8	63.7	38.6	18.0	3.7	4.8	58.5
12-13	70.0	95.4	38.6	18.0	3.7	45.8	99.5
13-14	65.9	156.5	38.6	18.0	3.7	97.5	151.2
14-15	70.9	151.8	38.6	18.0	4.1	98.8	152.9
1915-16	69.8	132.6	38.6	18.0	4.1	74.2	128.3
16-17	74.1	73.7	38.6	18.0	4.1	24.9	79.0
17-18	68.8	37.5	38.6	18.0	3.8	0	53.8
18-19	52.5	93.4	38.6	18.0	3.9	30.1	84.0
19-20	61.9	22.3	38.6	18.0	2.9	0	52.9
1920-21	31.3	141.3	38.6	18.0	3.7	60.2	113.9
21-22	58.7	64.7	38.6	18.0	3.9	3.1	57.0
22-23	66.4	45.0	38.6	18.0	3.7	0	53.7
23-24	57.7	13.0	38.6	18.0	2.3	0	52.3
24-25	18.4	131.6	38.6	18.0	4.2	19.9	74.1
1925-26	75.9	55.9	38.6	18.0	3.9	21.6	75.5
26-27	56.3	139.8	38.6	18.0	4.0	76.3	130.3
27-28	65.8	78.9	38.6	18.0	4.0	21.5	75.5
28-29	69.2	31.1	38.6	18.0	3.4	0	53.4
29-30	46.9	59.2	38.6	18.0	3.7	0	53.7
1930-31	52.4	26.1	38.6	18.0	2.6	0	52.6
31-32	25.9	62.3	38.6	18.0	2.9	0	52.9
32-33	35.3	63.8	38.6	18.0	3.5	0	53.5
33-34	45.6	41.5	38.6	18.0	3.2	0	53.2
34-35	33.9	89.0	38.6	18.0	4.0	0	54.0
1935-36	68.9	101.3	38.6	18.0	3.8	55.7	109.5
36-37	60.7	61.8	38.6	18.0	4.0	0	54.0
37-38	68.5	199.3	38.6	18.0	4.0	146.5	200.5
38-39	67.3	45.9	38.6	18.0	3.7	3.6	57.3
39-40	55.9	130.1	38.6	18.0	3.9	66.8	120.7
1940-41	65.3	133.5	38.6	18.0	3.9	72.8	126.7
41-42	72.1	134.0	38.6	18.0	4.0	77.6	131.6
42-43	74.5	103.2	38.6	18.0	3.9	59.4	113.3
43-44	64.4	36.0	38.6	18.0	3.4	0	53.4
44-45	55.6	82.1	38.6	18.0	3.4	20.0	70.0
1945-46	63.3	109.4	38.6	18.0	3.4	60.9	114.3
46-47	58.4	38.1	38.6	18.0	3.4	0	53.4
47-48	43.1	81.8	38.6	18.0	3.4	0	53.4
48-49	71.5	78.7	38.6	18.0	3.4	38.2	91.6
49-50	58.6	69.7	38.6	18.0	3.4	12.8	66.2
1950-51	62.1	142.8	38.6	18.0	3.4	93.5	146.9
51-52	58.0	141.5	38.6	18.0	3.4	86.5	139.9
52-53	59.7	136.7	38.6	18.0	3.4	75.3	128.7
53-54	67.8	130.9	38.6	18.0	3.4	74.3	127.7
54-55	71.0	50.9	38.6	18.0	3.4	4.0	57.4
1955-56	64.5	180.0	38.6	18.0	3.4	133.3	186.7
56-57	57.8	73.8	38.6	18.0	3.4	8.4	61.8
57-58	69.8	220.0	38.6	18.0	3.4	162.7	216.1
58-59	75.9	75.3	38.6	18.0	3.4	40.1	93.5
59-60	57.7	64.7	38.6	18.0	3.4	1.9	55.3
1960-61	67.1	103.4	38.6	18.0	3.4	52.0	105.4
61-62	65.4	70.0	38.6	18.0	3.4	24.4	77.8
62-63	57.6	127.9	38.6	18.0	3.4	56.2	109.6
63-64	75.9	68.9	38.6	18.0	3.4	35.2	88.6
AVERAGE	60.3	91.7	38.6	18.0	3.6	38.5	

1/ A total of 50,000 acre-feet is released annually for fishery maintenance, recreation, urban and agricultural uses combined. Fish maintenance releases are utilized in Tenmile Creek only and are available for other purposes in the lower basin.

Local Water Supply. When operated as shown in Table 16, the Cahto Project could yield 18,000 acre-feet of water for local use. Assuming a demand buildup as shown in Table 12 in Chapter 2, this yield can meet the needs of the South Fork Basin and the Lower Eel subunit until about 1990. This yield would ultimately be distributed in the following proportions: 12,500 acre-feet for irrigated agriculture, primarily in the Eel River Delta; 3,500 acre-feet for urban use; and 2,000 acre-feet for summer recreation use. Evaluated under the criteria described in Chapter 3, this water supply would provide a capitalized benefit of $12,100,000.

Flood Control. Cahto Reservoir could provide a 20,000 acre-foot flood control reservation between October 1 and April 1 of each year. Preliminary studies by the U. S. Army Corps of Engineers, previously discussed under "Project Features - Designs and Costs", showed that this amount of flood storage would provide average annual benefits of about $93,000. This amount capitalized for the 100-year period of evaluation would have a value of about $2,300,000.

Recreation. The Cahto Project would be ideally situated for recreation development. The project would support water-associated recreation use ranging from 538,000 visitor-days per year initially to about 3,757,000 visitor-days by the end of the period of analysis. Using the criteria described in Chapter 3, a value of $2.26 per visitor-day was determined for general recreation use at Cahto Reservoir. By applying this value to the projected visitor use presented in Table 13 of Appendix B, a total capitalized benefit for general recreation use of about $61,350,000 was determined. A portion of this benefit is credited to fishery enhancement in the following section. The total benefit for non-fishing recreation use at the Cahto Project would be about $58,800,000.

The recreation use estimates for the Cahto Project were based on maximum land acquisition and optimum development of suitable lands with a stable recreation pool. Thus, the estimates represent maximum potential recreation use.

Releases of water from Cahto Reservoir during the summer months would also enhance the potential for recreation use of natural pools along the South Fork Eel River. This enhancement could not be evaluated during this study due to lack of data. However, observation of the area during

the summer months indicated that heavy recreation use will occur wherever a natural pool in the river channel is accessible by automobile. Enhancement of the low summer streamflow, possibly coupled with development of public access to the stream channel or development of low recreation dams, could significantly affect the recreation potential of the South Fork Eel River Basin.

Fish and Wildlife Enhancement. The Department of Fish and Game found a significant potential for fishery enhancement at the Cahto Project, but found that there would be only incidental wildlife enhancement. Most of the fishery enhancement would be accomplished by the normal operation of the reservoir and is evaluated herein on the assumption that an adequate volume of water at a suitable temperature could be obtained from the reservoir.

Natural production of fish in Cahto Reservoir could support 46,000 angler-days of use annually. This level of use would be reached within the first decade of project life. Maintaining satisfactory angling at higher levels of use would require some kind of intensive management such as stocking catchable-sized fish. Assuming that angler use of the reservoir would remain at 46,000 angler-days per year through the life of the project, a general recreation benefit for fishing would be provided that would have a capitalized value of about $2,550,000.

Releases of water from Cahto Reservoir for urban and recreation use would maintain a flow in Tenmile Creek downstream from the dam that would exceed 20 cfs throughout the summer. This flow would enhance the nursery areas for juvenile fish in lower Tenmile Creek, increasing the spawning escapement by about 1,400 silver salmon and steelhead, the commercial catch by about 1,000 silver salmon, and the sport catch by about 500 silver salmon and steelhead. This increase would provide capitalized benefits of about $192,000.

A fishery maintenance release of 100 cfs from Cahto Reservoir beginning on October 15 would provide a minimum outflow from the South Fork Eel River of about 150 cfs. Flows of this magnitude could attract spawning king salmon into the basin before the fall rains begin. This early entry could cause a significant increase in angler use, as discussed in Chapter 3. The estimated increase in angling use would provide fishery enhancement benefits with a capitalized value of about $3,448,000.

In addition, a 100-cfs release from Cahto Reservoir from October 15 through December 31 could enhance spawning areas for king salmon in the South Fork Eel River below Benbow Dam. The Department of Fish and Game has estimated that this flow would increase the king salmon spawning population by about 1,400, the commercial catch by 2,200, and the sport catch by 600. These additional fish would have a capitalized value of about $310,000. Thus the total fishery enhancement benefit would be about $6,500,000.

Summary of Project Benefits. A summary of the estimated benefits for the Cahto Project is presented in Table 17. The present worth of the total benefits is $79,700,000.

TABLE 17

SUMMARY OF CAHTO PROJECT BENEFITS

Project Purpose	Present Worth of Total Benefits
Water Conservation	$12,100,000
Flood Control	2,300,000
Recreation	58,800,000
Fisheries Enhancement	6,500,000
TOTAL	$79,700,000

Economic Justification

The criterion used to measure the economic justification of a proposed water project is the ratio of benefits to costs. For a project to be economically justified, the primary tangible benefits must exceed the total project costs over the same period of time.

The Cahto Project, if constructed in 1975 and operated as shown in Table 16, would provide total benefits of $79,700,000 with a comparable total project cost of $37,700,000. The resulting benefit-cost ratio is 2.11 to 1.00. Therefore, the Cahto Project is economically justified.

The Panther Project

The Panther Project (Figure 8) would be located on the East Branch of the South Fork Eel River about one mile upstream from its confluence with the South Fork. A 240-foot dam would impound a reservoir of 80,200 acre-feet of water, covering 920 acres. The reservoir would be about 5 miles long and have a shoreline of almost 20 miles. The terrain surrounding the reservoir is very rugged, with very little level area suited to the development of onshore recreation facilities. The primary purpose of this project would be the development of additional water to serve the growing needs of the study area.

Hydrology

The drainage area at Panther damsite is 74.8 square miles and the mean annual runoff for the 50-year period from 1911 through 1960 is 147,900 acre-feet, or about 1,980 acre-feet per square mile. Runoff estimates (see Table 10 in Chapter 2) were derived from the records of stream gaging stations within the basin by an area-precipitation relationship.

The probable maximum flood with a peak discharge of 44,000 cfs was computed for Panther damsite. This flood flow was used in sizing diversion works and designing the spillway for the project.

Geology

Geologic exploration for the Panther Project was limited to surface geologic mapping of the damsite and reservoir area, a seismic refraction survey at the damsite, and drilling of six bucket auger holes in the terrace deposits on the lower left abutment. The results of the geologic investigation are presented in an office report, "Engineering Geology of Damsites, South Fork Eel River Study", which is on file in the Northern District office. The geology of Panther damsite is shown in Figure 9.

The principal foundation rocks at Panther damsite are mudstone, siltstone, and sandstone of the Panther Formation of Pliocene age. A considerable amount of Franciscan Formation greenstone is also present

in the upper left abutment. Much of the geologic structure of the site is partially obscured by overburden comprised of slide debris, soil, slopewash, and stream-deposited gravel and silt.

Landslides of various types and sizes occur throughout the watershed of the East Branch. Some loss of storage capacity should be anticipated due to silt loads in the stream and to active landslides moving into the reservoir area. Landslides into the reservoir are not considered a major threat to the safety of the dam, but the action of waves generated by landslides should be considered in the design of the dam.

It was concluded that the site will provide an adequate foundation for a properly designed earthfill dam and that the sandstone and shale on the right abutment will provide a suitable foundation for a chute spillway. Underlying rocks in the reservoir area are essentially tight and no leakage is expected. Sandstone at the damsite may be slightly permeable, and minor leakage through the foundation is possible. A grout curtain should be installed.

Construction Materials

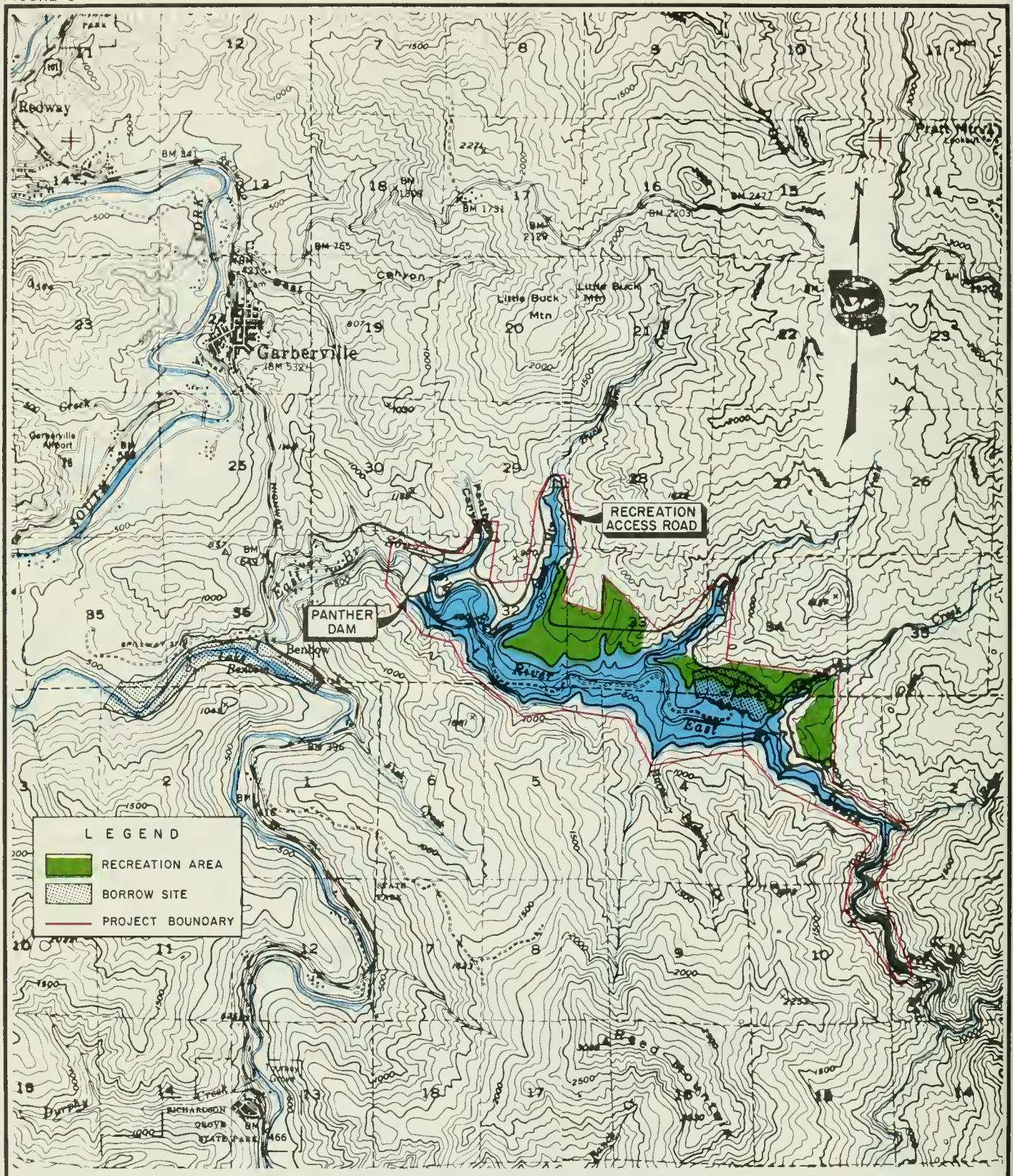
Sufficient material for the pervious and impervious zones of the dam are available at reasonable haul distances. The locations of proposed borrow areas are shown in Figure 8.

Panther Dam would require 5,575,000 cubic yards of fill material, of which 1,950,000 would be impervious core, 3,540,000 would be pervious shell, and 85,000 would be rock riprap.

Material for the impervious core section would be obtained from within the reservoir area. The proposed borrow area was explored by drilling 12 auger holes to an average depth of 19 feet. Samples of the material were tested and found to be suitable for use as impervious fill. Test results are included in the previously mentioned geology office report.

Material for the pervious shell of the dam would be obtained from the channel of the South Fork Eel River or from the lower East Branch channel. Based on field inspection of the sites, it was concluded that the gravels would be suitable for pervious fill material. Gravels from the East Branch channel would require special processing to remove excess fine material and a significant percentage of soft, unacceptable gravels.

FIGURE 8



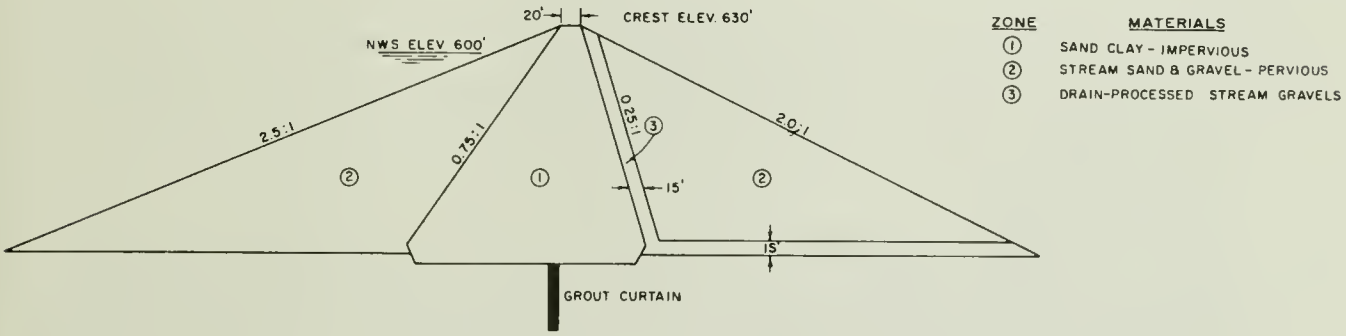
NORTH COASTAL AREA INVESTIGATION
SOUTH FORK EEL RIVER STUDY

PANTHER DAM
AND
RESERVOIR

Project Features - Designs and Costs

The Panther Project as proposed would consist of: (1) dam and appurtenant structures, (2) reservoir, and (3) recreation facilities. General project features are shown in Figure 9 and described in detail in the following sections.

Panther Dam. The dam would be a gravelfill section with a central impervious core, 240 feet high. The crest would be at elevation 630 feet, providing a freeboard of 13 feet above the maximum water surface elevation of 617 feet. This freeboard would protect the embankment from damage by waves created by landslides in the reservoir area. The various zones in the dam are shown in the drawing below.

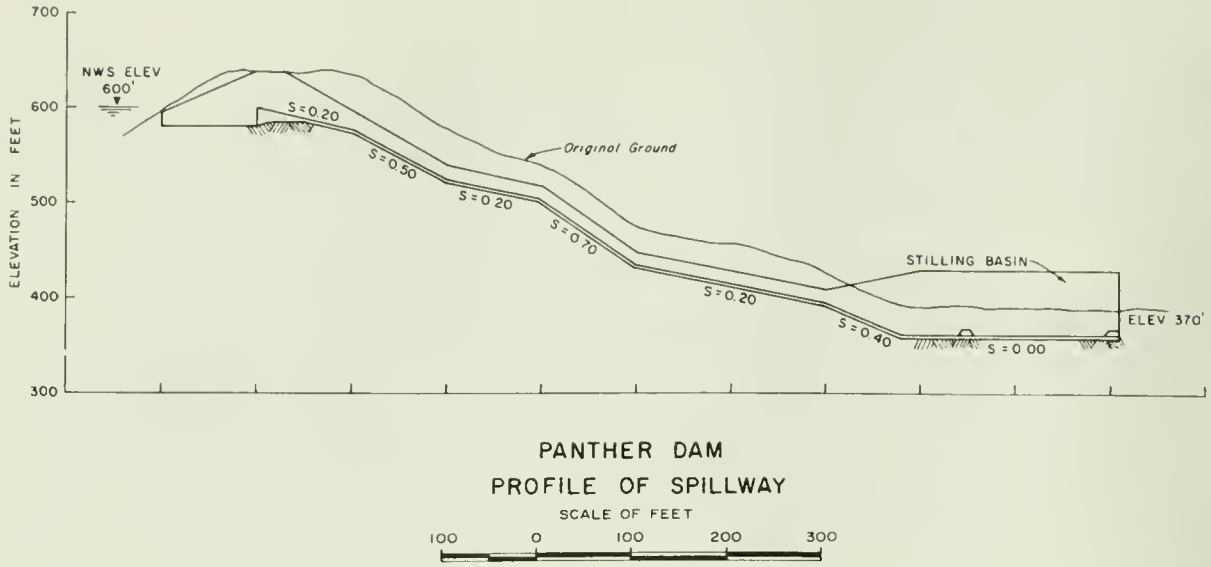


PANTHER DAM - MAXIMUM SECTION

SCALE OF FEET
100 0 100 200

Foundation preparation would consist of stripping to solid material, excavating a cut-off trench to bedrock, and grouting.

Spillway. A concrete-lined chute spillway would be located on the right dam abutment. The headworks would consist of a 185-foot ogee weir at elevation 600 feet. Downstream from the crest, the discharge chute would converge from 185 to 40 feet in width and terminate in a stilling basin. The spillway was designed to pass the estimated probable maximum flood (44,000 cfs) with a maximum pool elevation of 617 feet.



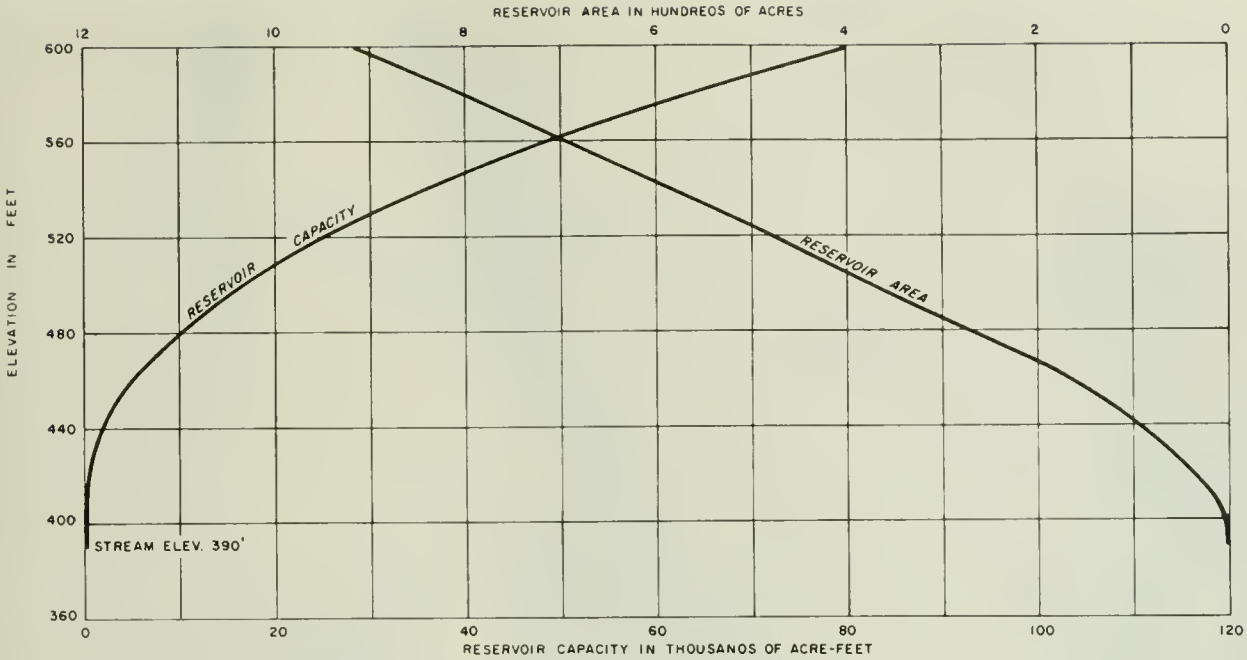
PANTHER DAM
PROFILE OF SPILLWAY
SCALE OF FEET
100 0 100 200 300

The headworks and spillway chute would be founded on sandstone and mudstone of the Panther Formation. The rapidly weathering mudstone would require a special sealing process immediately after excavation to prevent slaking.

A total of 256,000 cubic yards of soil and rock would be excavated for the spillway. A more extensive investigation of the rock will be required before it can be considered as dam embankment material.

Outlet Works. Discharge from the reservoir would be through a 30-inch steel pipe in a cut-and-cover diversion conduit, with release controlled by a 24-inch Howell-Bunger valve. Provisions would be made for withdrawing water from selected levels in the reservoir to control the temperature of releases. The outlet would discharge into the spillway stilling basin.

Panther Reservoir. The reservoir would have a gross storage capacity of 80,200 acre-feet at a normal water surface elevation of 600 feet, covering an area of 920 acres. About 2,175 acres of land would have to be acquired for the project, of which about 1,915 acres would be for the reservoir and 260 acres for recreation development. Reservoir capacity and water surface area at various water surface elevations are shown in the following graph.



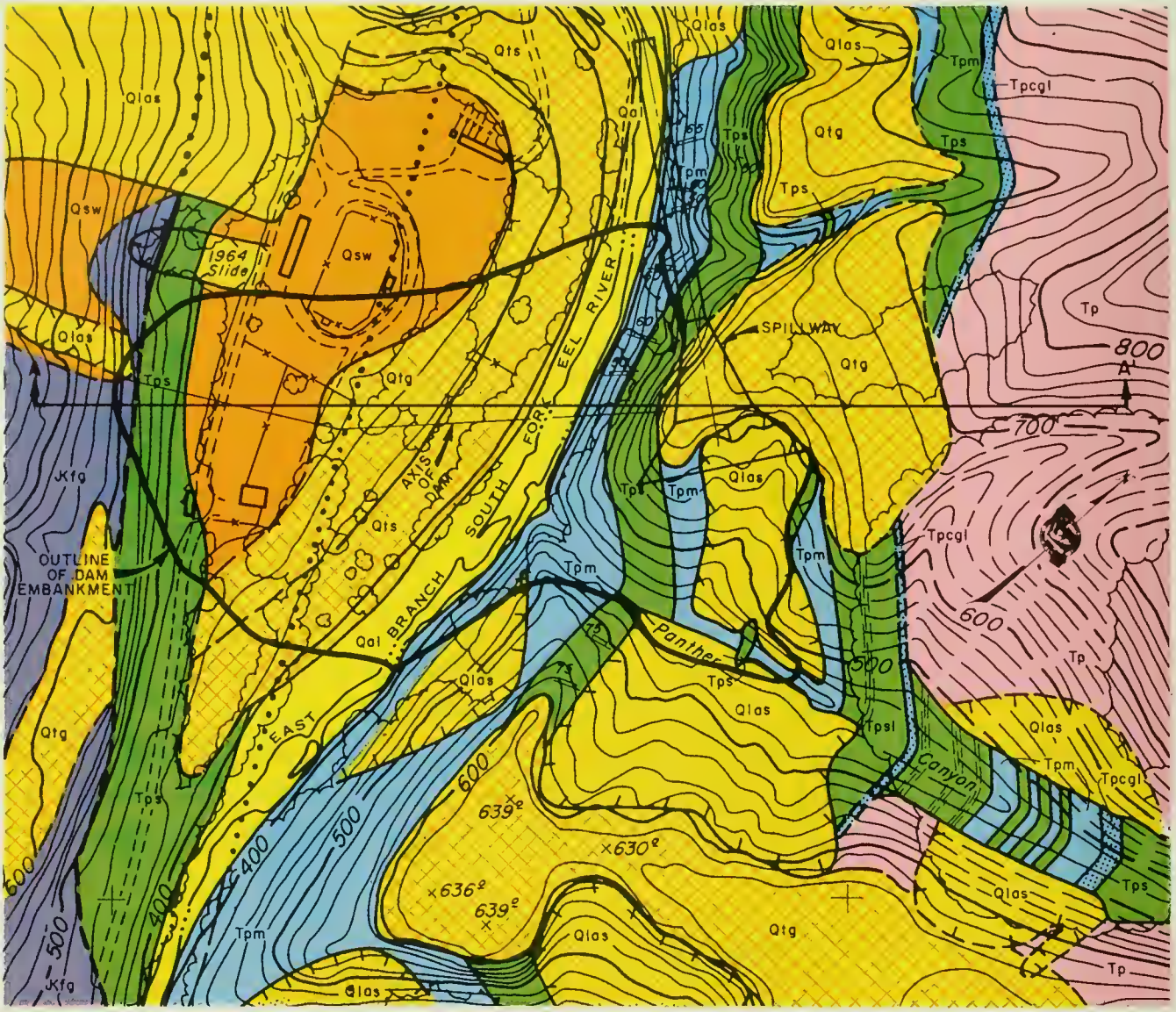
PANTHER RESERVOIR
AREA - CAPACITY CURVES

The reservoir would require clearing between the normal water surface elevation of 600 feet and the minimum elevation of 450 feet, an area of about 820 acres. No significant road or utility relocations would be required, but the project would require the construction of 8.5 miles of access roads.

Recreation Facilities. As described in Appendix B, the potential for recreation development at Panther Reservoir would be very limited due to lack of developable lands. The initial installation of facilities would use all of the available lands, and these facilities would be used to capacity in the first decade of project life. Recreation costs would include the facilities costs shown in Appendix B, the cost of additional lands required for recreation development, and access road costs.

Fish and Wildlife Preservation. Project costs for maintaining the fish and wildlife populations in the reservoir area were determined by the Department of Fish and Game. Estimates of the required facilities and costs are presented in Appendix C. These facilities include the development of deer range for mitigation purposes and the construction of a fish hatchery below Panther Dam.

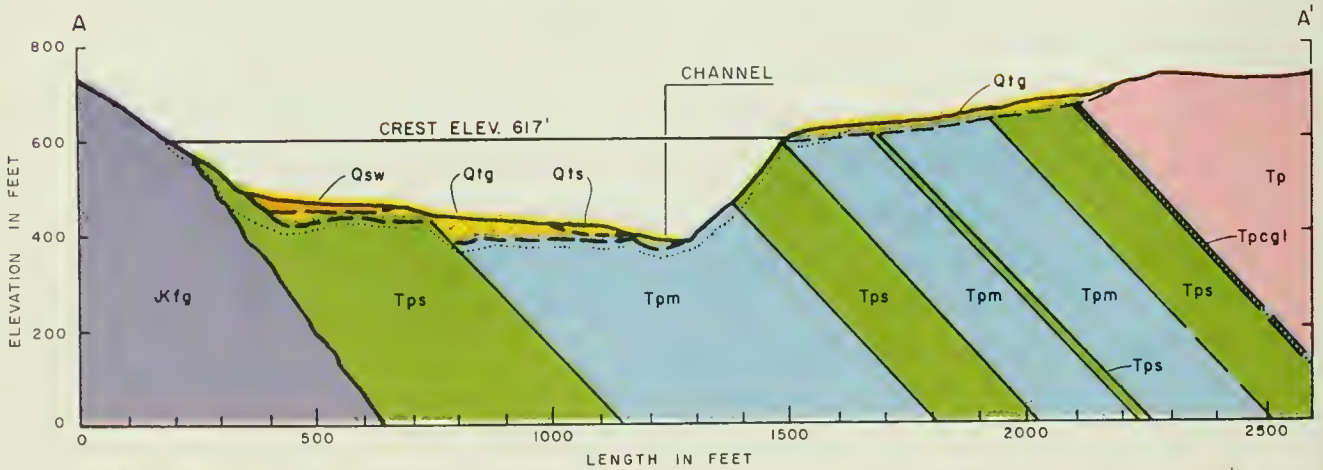
PANTHER PROJECT GEOLOGIC PLAN AND SECTION



SCALE OF FEET

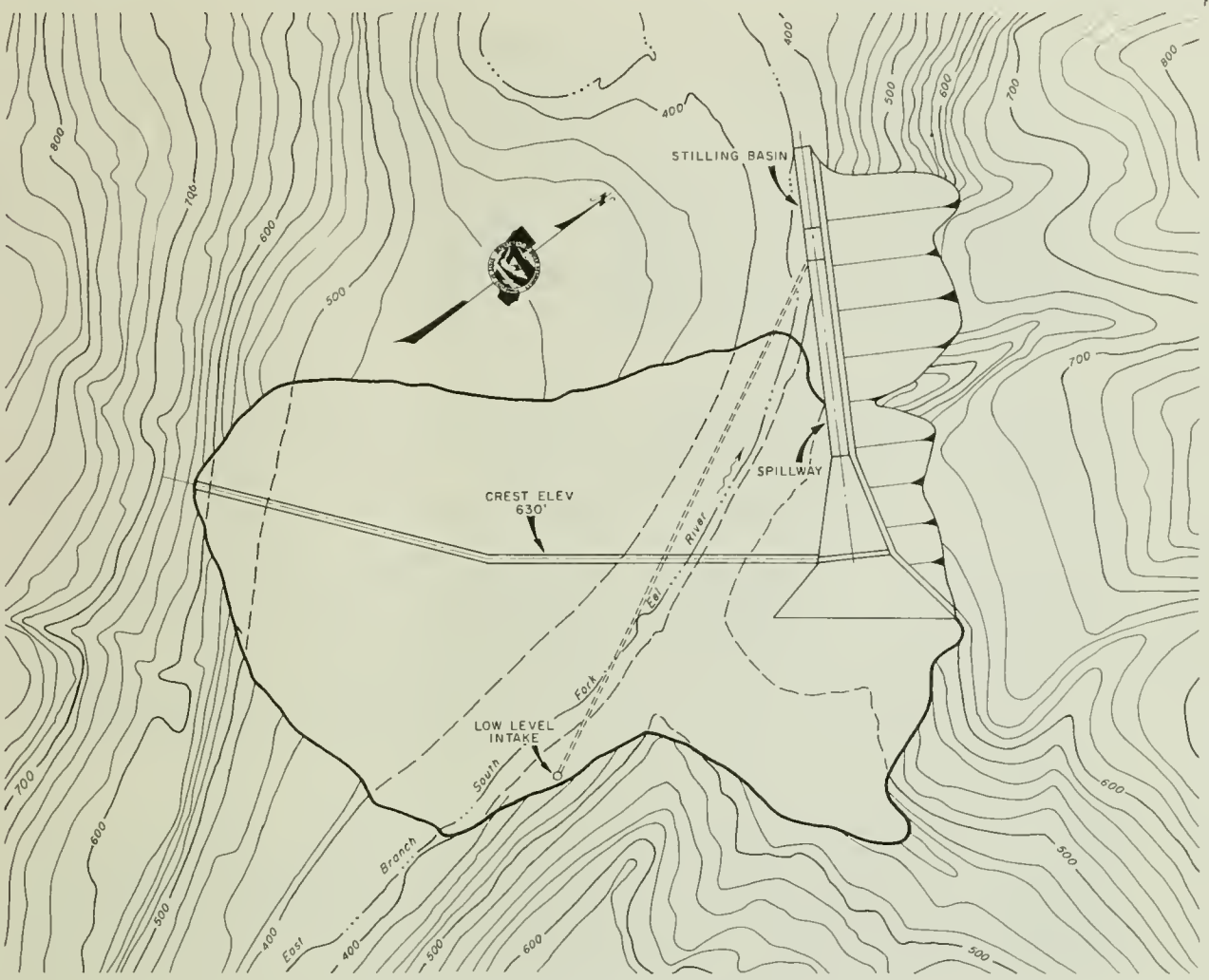
0 400 800

CONTOUR INTERVAL = 20 FEET



SECTION A-A'

PANTHER PROJECT GENERAL PLAN



SCALE OF FEET
200 0 200 400
CONTOUR INTERVAL = 20 FEET

LEGEND

Qal — STREAM DEPOSITS
Deposits of stream gravels, silts and sands. Derived from the Franciscan and Panther Formations.

Qsw — SLOPE WASH
Deposits of rocky, clayey soil. The deposits mantle the slopes at the damsite and in reservoir areas.

Qls — LANDSLIDE DEBRIS
Slides and slumps of various types and sizes which consists of soil and rock fragments.

Qtg — TERRACE DEPOSITS
Unconsolidated deposits of cobbles and gravels (Qtg.) as well as unconsolidated silts and sands (Qts.).

Tp — PANTHER FORMATION
Undifferentiated marine sandstones, mudstones, siltstones, and minor conglomerates.

Tpm — MUDSTONE (Panther Formation)
Includes associated siltstone. Numerous landslides originate on the weathered surfaces of this unit. Dashed lines indicate shale beds in sandstone.

Tps — SANDSTONE (Panther Formation)
Generally massive fine grained uncemented friable rock with occasional pebbly zones and minor cross bedding.

Tpcgl — CONGLOMERATE (Panther Formation)
Generally forms resistant ridges. Siltstone and mudstone units are present.

JKfg — GREENSTONE
Altered mafic volcanic rock. Moderately fractured, with numerous local variations. Generally resistant to erosion.

SYMBOLS

25 — Attitude of beds

40 — Attitude of joints

Geologic contact - dashed where approximately located and dotted where concealed.

Flood Control. Several proposals for flood control were considered in evaluating the Panther Project, with flood storage reservations ranging from 20,000 to 80,000 acre-feet. Economic analysis on the basis of the criteria given in Chapter 3 showed that the cost of providing flood control would exceed the expected benefits for the entire range of storage reservations. Therefore, the purpose of flood control could not be included in the formulation of this project.

Water Conservation. Project costs for water conservation are normally determined by defining specific service areas and making cost estimates of facilities to deliver water to the service areas. In this study, an approximate unit cost was developed for various water uses and applied to the conservation yield of the project. From the projected demand for water in Chapter 2 and the unit costs shown in Chapter 3, the capital cost for diverting and pumping the conservation yield from the Panther Project was estimated to be about $10,750,000. Approximately 10 percent of this amount would be the initial capital cost, with the balance coming as future expenditures.

Summary of Costs. A summary of the estimated project costs during the 100-year period of analysis is presented in Table 18. The initial capital outlay for this project is estimated to be $22,600,000. The present worth of the total expenditure during the period of analysis is estimated to be $36,200,000.

Project Accomplishments and Benefits

The Panther Project was formulated to serve the purposes of local water supply, recreation, and fish and wildlife enhancement. In the analysis of this project, a number of operation studies were made to define project yields and compare alternative sizes of reservoirs. The optimum scale of development would be near the size presented here. However, a more advanced study, including a refined analysis of water service areas and associated benefits, would be necessary to confirm the size of the project.

TABLE 18

SUMMARY OF PANTHER PROJECT COSTS

Project Feature	Capital Cost	Operation, Maintenance, Replacement, and General Expense*	Present Worth of Total Expenditure Over 100 Years
Panther Dam, Reservoir, and Appurtenances	$19,900,000	$ 900,000	$20,800,000
Recreation Facilities	800,000	1,050,000	1,850,000
Fish and Wildlife Preservation	800,000	2,000,000	2,800,000
Water Conservation - Diversion and Pumping	1,100,000	9,650,000	10,750,000
TOTAL	$22,600,000	$13,600,000	$36,200,000

* Includes present worth of all future additions and expenditures.

Several combinations of project purposes were studied for the Panther Project. For most of these combinations the project costs exceeded the expected benefits by a substantial margin, due primarily to the high cost of dam construction. The one combination for which benefits would be greater than costs includes as the principal purpose the provision of an industrial water supply for the lower Eel River area.

The Department's Bulletin No. 142-1 projected an increase in the industrial water requirement within the lower Eel River area due to the construction of a 500 ton-per-day pulp mill, probably before the year 1990. Such a mill would require a firm annual water supply of 35,000 acre-feet, which could logically be derived from the Panther Project.

The formulation of the Panther Project as presented herein assumes the concurrent development of an industrial water requirement of 35,000 acre-feet per year. The accomplishments of such a project and the associated benefits are described in the following sections.

Local Water Supply. When operated as shown in Table 19, the Panther Project could provide a firm yield of 82,600 acre-feet of water per year, of which 63,000 acre-feet could be released on a schedule to meet local needs. Industrial development in the Lower Eel subunit would

TABLE 19

SUMMARY OF MONTHLY OPERATION STUDIES
OF PANTHER RESERVOIR

80,200 Acre-Feet of Storage
(In 1,000 Acre-Feet)

Runoff Year	Storage on October 1	Inflow	Annual Water Releases and Losses					
			Fishery1/ Maintenance	Recreation Agric.-Urban Yield	Industrial Yield	Evaporation	Spill	Total
1911-12	54.3	110.7	60.0	28.0	35.0	1.8	24.1	108.5
12-13	56.5	156.8	60.0	28.0	35.0	1.8	77.0	161.4
13-14	51.9	240.9	60.0	28.0	35.0	1.8	155.2	239.6
14-15	53.2	234.5	60.0	28.0	35.0	1.8	151.9	236.3
1915-16	51.4	208.6	60.0	28.0	35.0	1.8	121.0	205.4
16-17	54.6	125.3	60.0	28.0	35.0	1.8	42.4	126.8
17-18	53.1	70.0	60.0	28.0	35.0	1.8	0	84.4
18-19	38.7	154.1	60.0	28.0	35.0	1.8	58.0	142.4
19-20	50.4	44.9	60.0	28.0	35.0	1.1	0	83.7
1920-21	11.6	220.6	60.0	28.0	35.0	1.7	98.6	182.9
21-22	49.3	112.0	60.0	28.0	35.0	1.8	24.4	108.8
22-23	52.5	82.1	60.0	28.0	35.0	1.7	1.1	85.4
23-24 2/	49.2	27.8	30.0	28.0	35.0	1.3	0	42.6
24-25	34.4	207.2	60.0	28.0	35.0	1.7	103.2	187.5
1925-26	54.0	98.7	60.0	28.0	35.0	1.8	21.1	105.5
26-27	47.2	218.2	60.0	28.0	35.0	1.8	130.0	214.4
27-28	51.0	133.1	60.0	28.0	35.0	1.8	48.5	132.9
28-29	51.2	59.7	60.0	28.0	35.0	1.4	0	84.0
29-30	26.9	103.7	60.0	28.0	35.0	1.8	0	84.4
1930-31	46.2	51.2	60.0	28.0	35.0	1.3	0	83.9
31-32	13.5	108.6	60.0	28.0	35.0	1.8	0	84.4
32-33	37.7	110.5	60.0	28.0	35.0	1.8	8.8	93.2
33-34	55.0	76.4	60.0	28.0	35.0	1.8	0	84.4
34-35	47.0	147.7	60.0	28.0	35.0	1.8	58.2	142.6
1935-36	52.1	165.3	60.0	28.0	35.0	1.8	81.8	166.2
36-37	51.2	107.8	60.0	28.0	35.0	1.8	20.5	104.9
37-38	54.1	296.9	60.0	28.0	35.0	1.8	213.4	297.8
38-39	53.2	83.5	60.0	28.0	35.0	1.8	5.4	89.8
39-40	46.9	205.3	60.0	28.0	35.0	1.8	116.5	200.9
1940-41	51.3	208.1	60.0	28.0	35.0	1.8	119.6	204.0
41-42	55.4	210.8	60.0	28.0	35.0	1.8	122.2	206.6
42-43	59.3	168.2	60.0	28.0	35.0	1.8	86.5	170.9
43-44	56.9	67.3	60.0	28.0	35.0	1.8	0	84.4
44-45	39.8	137.2	60.0	28.0	35.0	1.8	38.2	122.6
1945-46	54.4	176.9	60.0	28.0	35.0	1.8	98.0	182.4
46-47	48.9	71.1	60.0	28.0	35.0	1.8	0	84.4
47-48	35.6	136.9	60.0	28.0	35.0	1.8	30.8	115.2
48-49	57.3	132.7	60.0	28.0	35.0	1.8	55.6	140.0
49-50	50.0	118.8	60.0	28.0	35.0	1.8	32.9	117.3
1950-51	51.5	223.2	60.0	28.0	35.0	1.8	140.7	225.1
51-52	49.6	220.6	60.0	28.0	35.0	1.8	133.8	218.2
52-53	52.0	214.1	60.0	28.0	35.0	1.8	122.4	206.8
53-54	59.3	206.9	60.0	28.0	35.0	1.8	129.9	214.3
54-55	51.9	91.7	60.0	28.0	35.0	1.8	5.8	90.2
1955-56	53.4	271.8	60.0	28.0	35.0	1.8	191.4	275.8
56-57	49.4	124.1	60.0	28.0	35.0	1.8	32.7	117.1
57-58	56.4	280.4	60.0	28.0	35.0	1.8	201.4	285.8
58-59	51.0	113.8	60.0	28.0	35.0	1.8	31.1	115.5
59-60	49.3	135.3	60.0	28.0	35.0	1.8	43.1	127.5
1960-61	57.1	151.0	60.0	28.0	35.0	1.8	69.0	153.4
61-62	54.7	98.0	60.0	28.0	35.0	1.8	18.9	103.3
62-63	49.4	183.7	60.0	28.0	35.0	1.8	94.5	178.9
63-64	54.2	106.5	60.0	28.0	35.0	1.8	28.3	112.7
AVERAGE	48.9	147.4	60.0	28.0	35.0	1.8	63.9	

1/ A total of 82,600 acre-feet is released annually for fish maintenance, recreation, urban and agricultural uses combined. Fish maintenance releases are utilized in the East Branch only, and are available for other purposes in the lower basin.

2/ A deficiency of 50% in fishery maintenance releases was taken in this year.

use 35,000 acre-feet per year. The additional 28,000 acre-feet of yield could meet the urban, agricultural, and recreational water needs of the South Fork Basin and Lower Eel subunit until about 2005.

Evaluated under the criteria described in Chapter 3, this water supply would provide a capitalized benefit of $17,400,000 for industrial use and $16,600,000 for agricultural, urban, and recreation use, for a total benefit of $34,000,000.

Recreation. The Panther Project has very limited potential for recreation development. The Department of Parks and Recreation has estimated that the developable lands around Panther Reservoir would support water-associated recreation use of up to 56,000 visitor-days per year. The recreation facilities would be used to capacity throughout the life of the project. Of this, 7,500 visitor-days per year would be angling use and 48,500 visitor-days would be general recreation use. Using the criteria described in Chapter 3, a value of $1.85 per visitor-day was determined for general recreation use at Panther Reservoir. Applying this value to the projected recreation use presented in Appendix B, a total capitalized benefit for general recreation use of $2,550,000 was determined. A portion of this benefit is credited to fishery enhancement in the following section. The total benefit for non-fishing recreation use at the Panther Project would be $2,200,000.

Fish and Wildlife Enhancement. The Department of Fish and Game determined that there would be a significant potential for fishery enhancement at the Panther Project, but found that there would be only incidental wildlife enhancement. Most of the fishery enhancement would be accomplished by the water supply operation of the reservoir and is evaluated on the assumption that an adequate volume of water at a suitable temperature could be obtained from the reservoir.

Natural production of fish in Panther Reservoir could support 7,500 angler-days of use per year. This level of use would be reached within the first decade of project life. Maintaining satisfactory angling at higher levels of use would require some kind of intensive management such as stocking catchable-sized fish. Assuming that angler use of the reservoir would remain at 7,500 angler-days per year through the life of the project, a general recreation benefit for fishing would be provided that would have a capitalized value of about $350,000.

Releases of water from Panther Reservoir for urban, industrial, and recreation use would maintain a flow in the East Branch downstream from the dam that would exceed 40 cfs throughout the summer. This flow would enhance the nursery areas for juvenile fish in the lower East Branch and South Fork Eel River, thereby increasing the annual spawning escapement of silver salmon and steelhead by about 3,500 fish, the commercial catch by about 3,100 silver salmon, and the sport catch by about 1,300 silver salmon and steelhead and about 17,500 trout. This enhancement would provide capitalized benefits of about $950,000.

A fishery maintenance release of 150 cfs from Panther Reservoir beginning on October 15 would provide a minimum outflow from the South Fork Eel River of about 200 cfs. Flows of this magnitude could attract spawning king salmon into the basin before the fall rains begin. This early entry could cause a significant increase in angler use, as discussed in Chapter 3. The estimated increase in angling use would provide fishery enhancement benefits with a capitalized value of about $3,450,000.

In addition, the release of 150 cfs from Panther Reservoir from October 15 through December 31 could enhance spawning areas in the South Fork Eel River below Benbow Dam. The Department of Fish and Game has estimated that this flow would increase the king salmon spawning population by about 1,200, the commercial catch by 1,900, and the sport catch by about 500. These additional fish would have a capitalized value of about $250,000.

Summary of Project Benefits. A summary of the estimated benefits for the Panther Project is presented in Table 20. The present worth of the total benefits is $41,200,000.

Economic Justification

The criterion used to measure the economic justification of a proposed water project is the ratio of benefits to costs. For a project to be economically justified, the primary tangible benefits must exceed the total project costs when compared over the same period of time.

TABLE 20

SUMMARY OF PANTHER PROJECT BENEFITS

Project Purpose	Present Worth of Total Benefits
Water Conservation - Industrial	$17,400,000
Water Conservation - Other	16,600,000
Recreation	2,200,000
Fisheries Enhancement	5,000,000
TOTAL	$41,200,000

The Panther Project, if constructed in 1975 and operated as shown in Table 19, would provide total benefits of $41,200,000 with a comparable total project cost of $36,200,000. The resulting benefit-cost ratio is 1.14 to 1.00. Therefore, the Panther Project as presented herein is economically justified. However, this justification could be negated if the demand for conserved water does not develop as assumed or if prior construction of the Cahto Project meets part of the water requirement of the area. The projected growth of the area's water requirement assumes an expansion of the pulp and paper industry in the Eel River Delta prior to the year 1990.

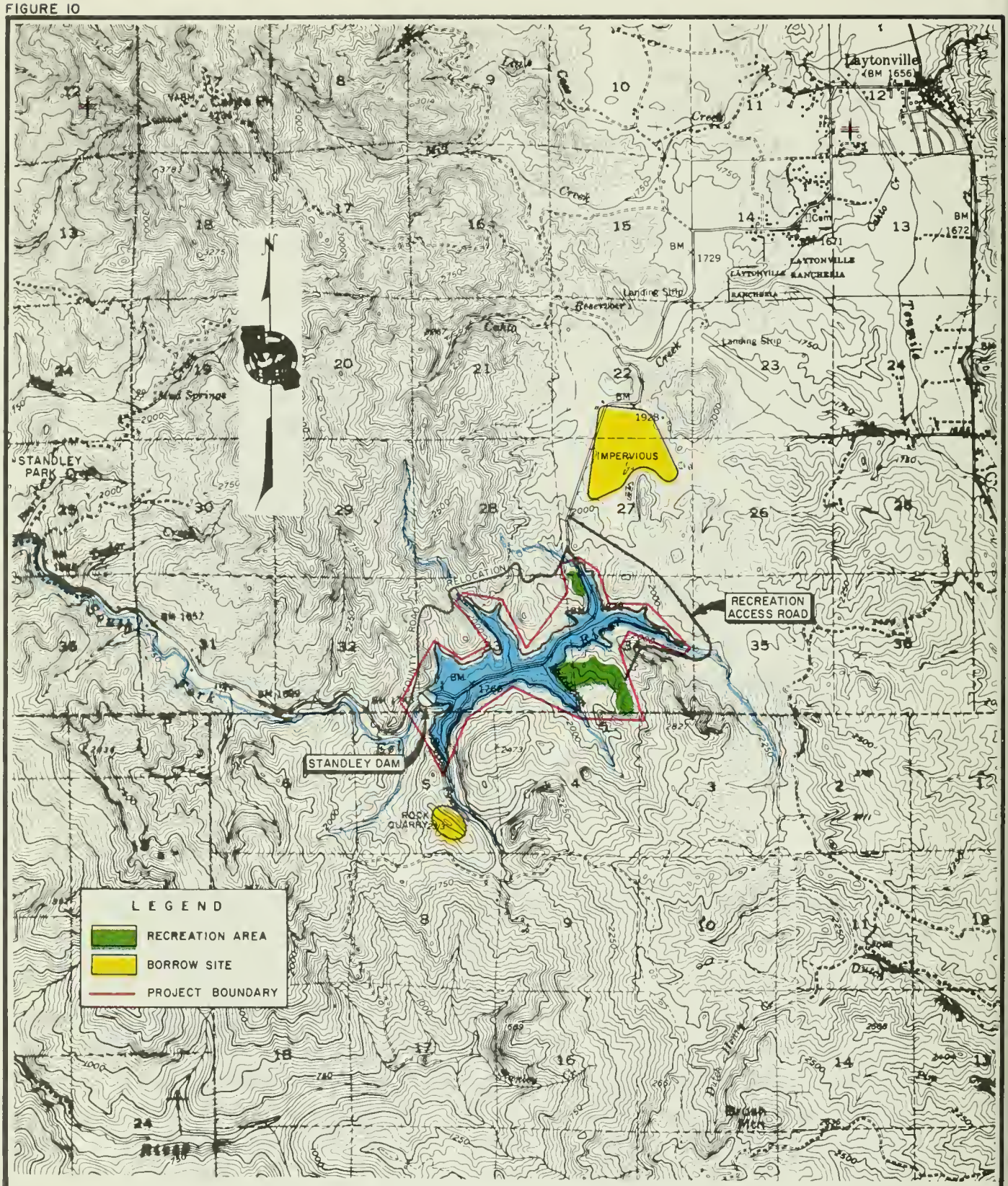
The Standley Project

The Standley Project (Figure 10) is located on the upper South Fork Eel River about five miles upstream from the community of Branscomb. A 163-foot high dam would impound a reservoir of 16,500 acre-feet of water, covering an area of 320 acres. The reservoir would be about two miles long and have a shoreline of about 10 miles. The primary purpose of this project would be the development of a water supply to augment the low summer flows in the upper South Fork for fishery enhancement and to serve the growing needs of the lower South Fork Basin.

Hydrology

The drainage area at Standley damsite is 7.1 square miles and the mean annual runoff for the 50-year period from 1911 through 1960 is 16,900 acre-feet, or about 2,380 acre-feet per square mile. Runoff estimates (see Table 7 in Chapter 2) were derived from the records of the

FIGURE 10



NORTH COASTAL AREA INVESTIGATION
SOUTH FORK EEL RIVER STUDY

STANDLEY DAM
AND
RESERVOIR

SCALE OF MILES
0 1/2 2

stream gaging station "South Fork Eel River near Branscomb" which is located about 12 miles downstream from Standley damsite.

A probable maximum flood with a peak discharge of 14,000 cfs was computed for Standley damsite. This flood flow was used in the design of the spillway for the project.

Geology

Geologic exploration at Standley damsite was limited to surface geologic mapping and a seismic refraction survey. The results of the geologic investigation are presented in an office report, "Engineering Geology of Damsites, South Fork Eel River Study", which is on file in the Northern District office.

Standley damsite and reservoir area are underlain by rocks of the Franciscan Formation. Franciscan sandstone, siltstone, shale, and conglomerate of marine sedimentary origin were found at the site. Most of these underlying rock formations are obscured by locally deep overburden, consisting primarily of slope wash and landslides. This mantle of surficial material makes geologic mapping difficult and results in speculative interpretations. The general geologic structure appears to consist of a thick sequence of marine sediments that have been folded and faulted. There are indications that a fault passes through the left abutment and it is reasonable to suspect the presence of other faults at the damsite concealed by overburden. Considerable subsurface exploration will be necessary at the damsite before the foundation can be adequately evaluated.

The cursory investigative work thus far completed indicates that the site is probably not suitable for a dam over 160 feet in height because of possible leakage through a fairly thin saddle section south of the site which separates the South Fork Eel River from Section Four Creek.

Construction Materials

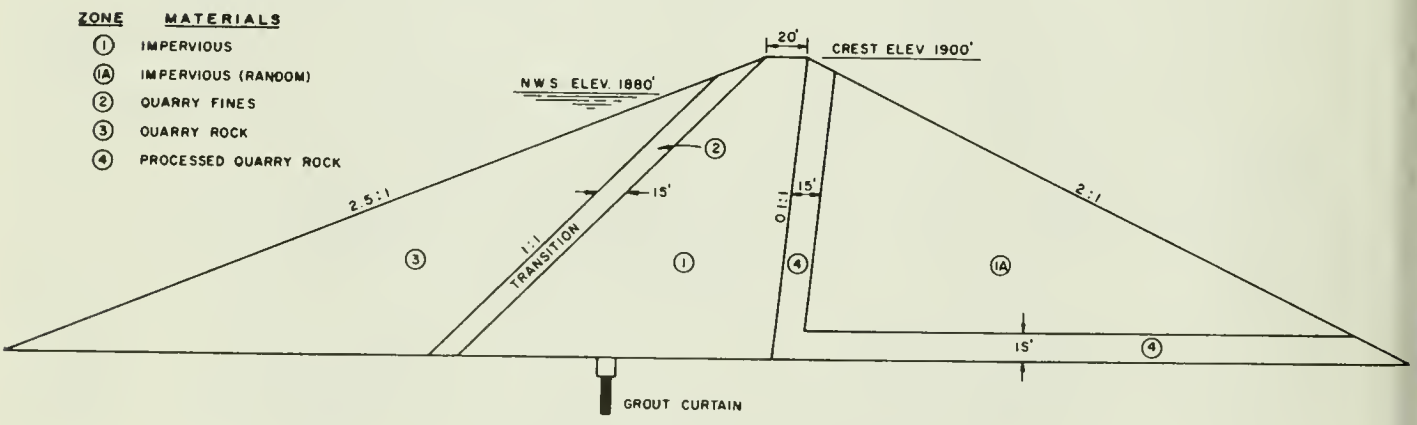
The exploration for construction materials for the Standley Project was limited because of lack of time and funds. No drilling, sampling, or testing was done on any of the proposed borrow sites. The borrow areas shown on Figure 10 were evaluated on the basis of a surface examination.

Standley Dam would require 1,340,000 cubic yards of fill material, of which 700,000 would be impervious core and 640,000 would be pervious shell. Material for the impervious core section would be obtained from a small valley about one-half mile northeast of the reservoir area. From surficial observations it appears that volumes far in excess of those required are present. The pervious shell of the dam would be constructed of rock quarried from a large body of Franciscan greenstone, about one-half mile south of the damsite. The presence of undesirable rock types such as serpentine and chert will necessitate further exploration to locate the most suitable borrow site.

Project Features - Designs and Costs

The Standley Project as proposed would consist of: (1) dam and appurtenant structures, (2) reservoir, and (3) recreation facilities. General project features are shown in Figure 11 and described in detail in the following sections.

Standley Dam. The dam would be an earth-rock section 163 feet high. The crest would be at elevation 1,900 feet, providing a freeboard of 10 feet above the maximum water surface elevation of 1,890 feet. The various zones in the dam are shown in the sketch below. Foundation preparation would consist of stripping to solid material and grouting.



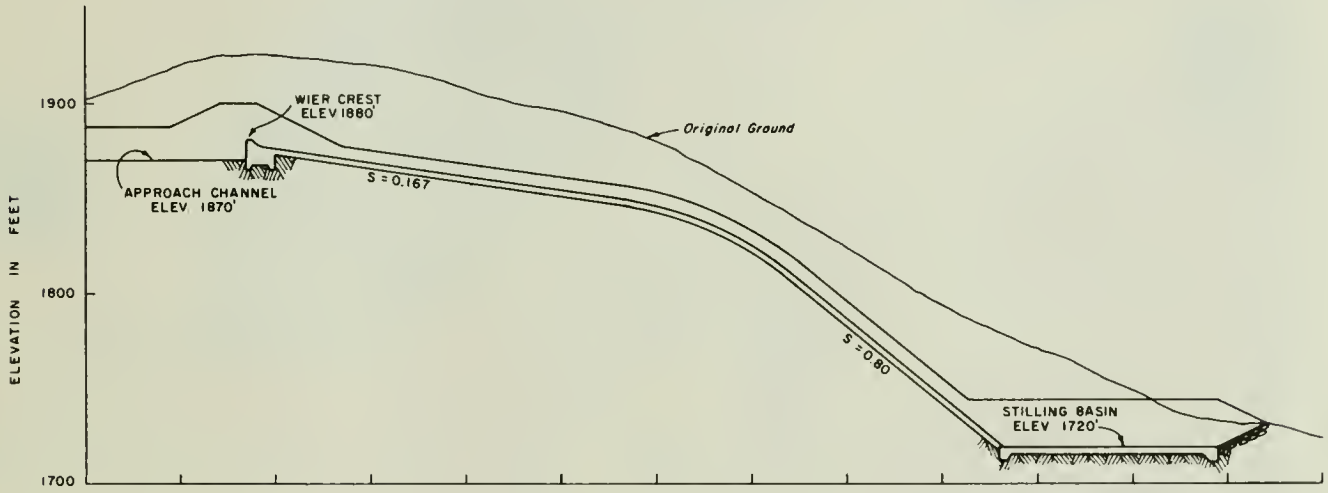
STANDLEY DAM - MAXIMUM SECTION

SCALE OF FEET

50 0 50 100

Spillway. A concrete-lined chute spillway would be located on the left abutment. The headworks would consist of a 110-foot-long ogee weir at elevation 1,880 feet. Downstream from the weir crest the discharge chute would converge from 110 to 70 feet in width and terminate in a stilling basin. The spillway was designed to pass the probable maximum flood of 14,000 cfs with a maximum pool elevation of 1,890 feet.

The spillway site was selected on the basis of surface geologic investigation. It appears that the left abutment location is the only site which has a suitable foundation and which would be clear of potential landslides that would endanger the spillway structure. The major portion of the spillway would be founded on a hard sandstone formation.

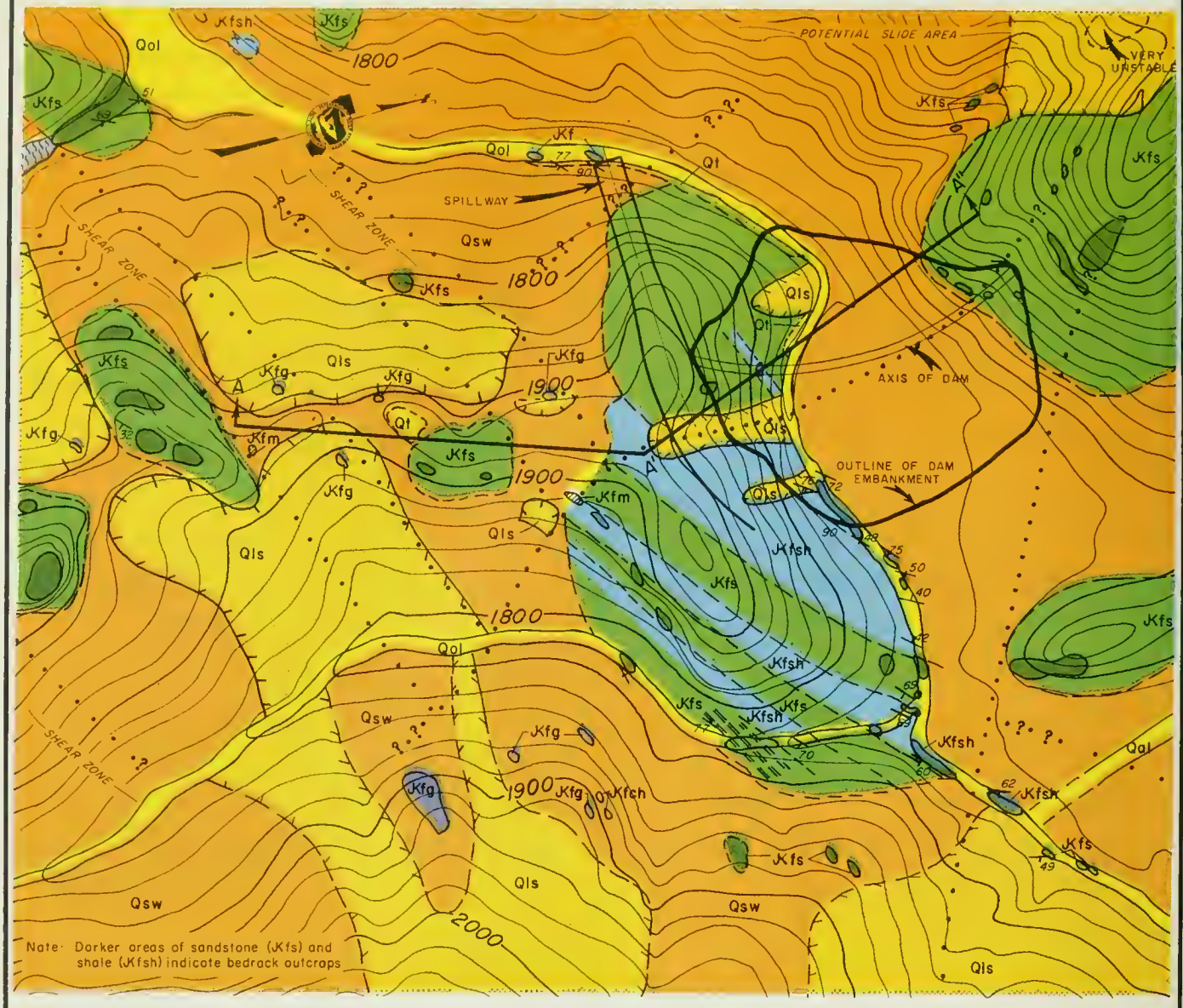


STANDLEY DAM
PROFILE OF SPILLWAY
SCALE OF FEET
50 0 50 100 150

Outlet Works. Discharge from the reservoir would be through a 30-inch steel pipe in a cut-and-cover diversion conduit, with release controlled by an 18-inch Howell-Bunger valve. Provisions would be made for withdrawing water from selected levels in the reservoir to control the temperature of releases. The outlet would discharge into the stream channel below the dam.

Standley Reservoir. The reservoir would have a gross storage capacity of 16,500 acre-feet at a normal water surface elevation of

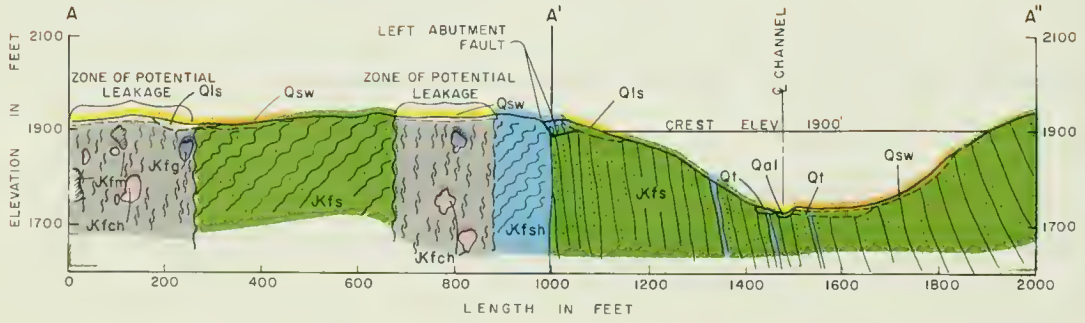
STANDLEY PROJECT GEOLOGIC PLAN AND SECTION



SCALE OF FEET

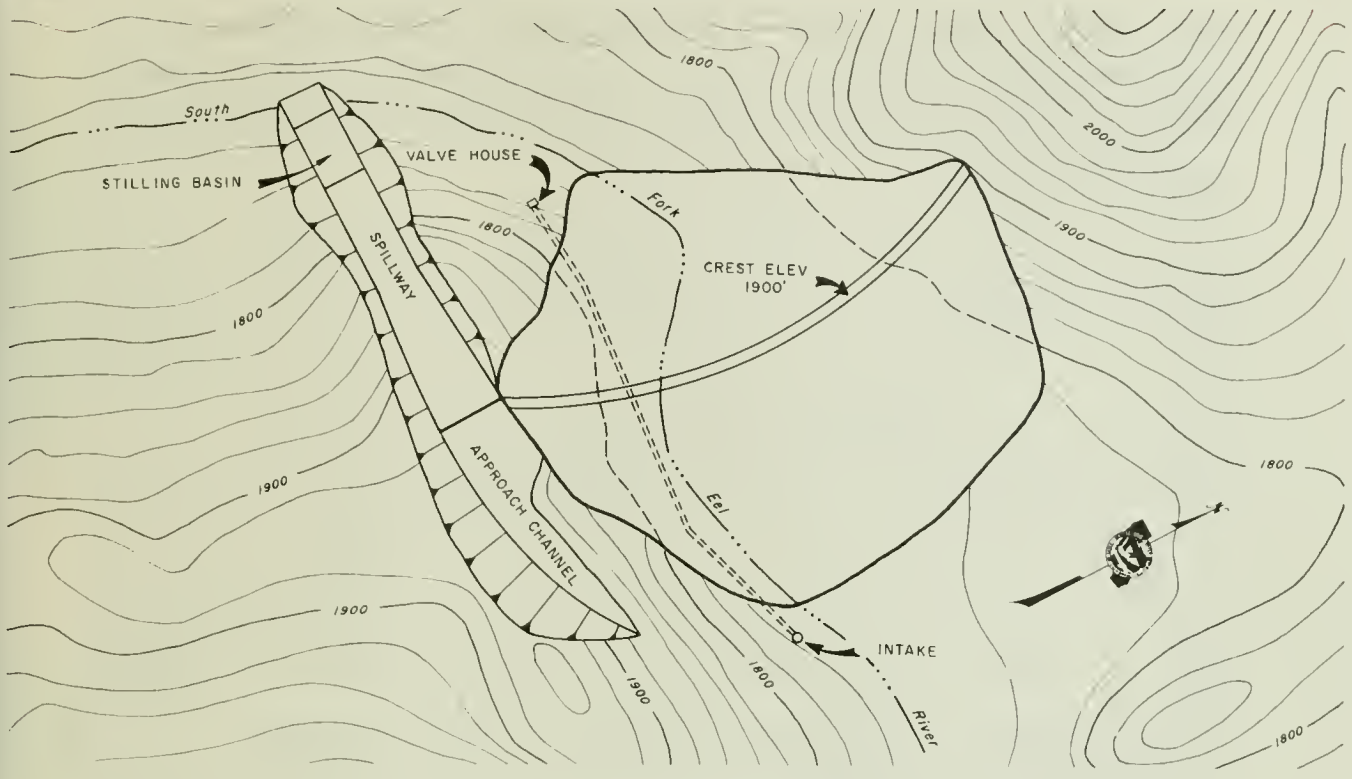
200 0 200 400

CONTOUR INTERVAL 20'



SECTION A-A'-A"

STANDLEY PROJECT GENERAL PLAN



SCALE OF FEET

200 0 200 400

CONTOUR INTERVAL=20 FEET

LEGEND

Qal STREAM DEPOSITS
Consists of unconsolidated gravels, silts and sands. Deposits are generally thin and discontinuous.

Qsw SLOPE WASH
Consists of locally deep deposits of soil and weathered rock debris. Where deposits are deep and slopes are steep potential slide conditions exist.

Qls LANDSLIDE DEBRIS
Slides and slumps of various sizes and depths consisting of a chaotic distribution of soil and rock debris.

Qt TERRACE DEPOSITS
Includes slightly consolidated deposits of sand and gravel. Appear to be generally thin and discontinuous. Older terraces on same ridge tops.

Jfs SANDSTONE
Generally massive, fine grained, well indurated moderately fractured graywacke. Includes minor amounts of interbedded conglomerates.

Jfsh SHALE AND SILTSTONE
Generally moderately fractured and locally crumpled.

Jfg GREENSTONE
Locally deeply weathered and moderately fractured. Associated with serpentine and/or chert.

Jfch CHERT
Hard, brittle, well-fractured, red to green in color and generally contorted.

Jfm METAMORPHICS
Includes meta-sandstone, meta-greenstone, meta-chert, usually schistone.

SYMBOLS

25 — Attitude of bedding

Geologic contact, dashed where approximately located.

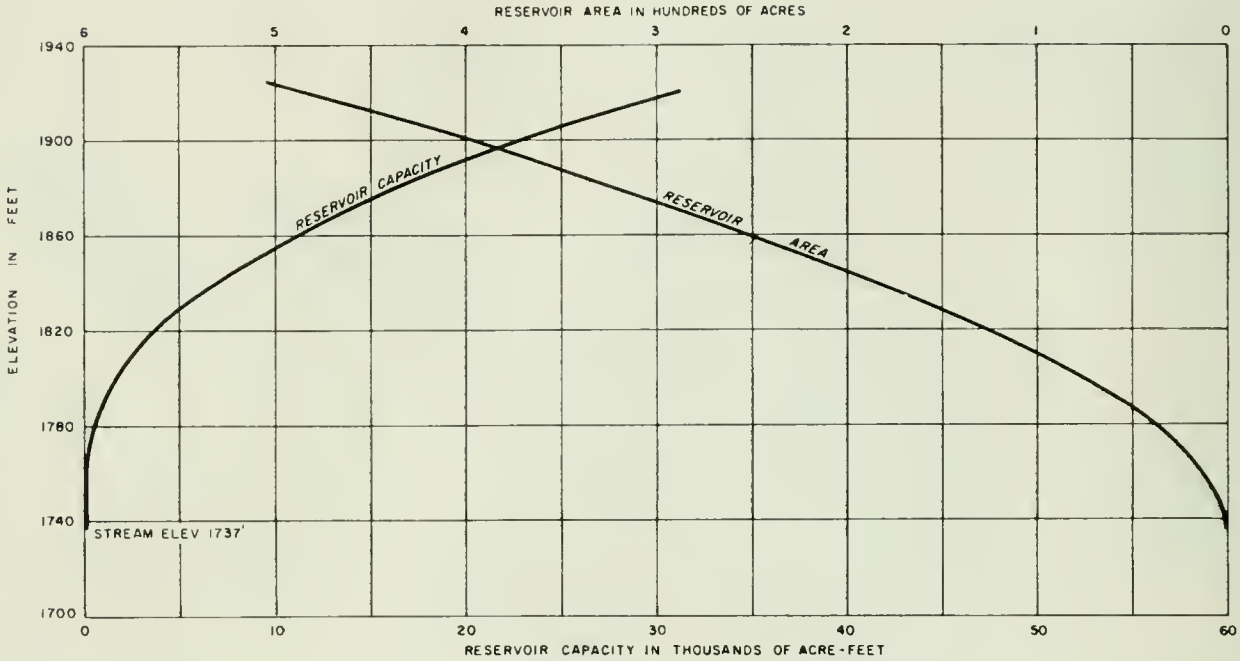
Fault, dotted, where concealed

Shear zone, dotted where concealed. Question marks where presence not certain.

Possible fault

Disturbed bedding - crumpled and/or lightly foliated.

1,880 feet, covering an area of 320 acres. About 1,370 acres of land would have to be acquired for the reservoir and recreation development. Reservoir capacity and water surface area at various water surface elevations are shown in the following graph.



STANDLEY RESERVOIR
AREA-CAPACITY CURVES

The reservoir would require clearing between the normal water surface elevation of 1,880 feet and the minimum elevation of 1,850 feet, an area of about 110 acres. The project would require the relocation of 2.4 miles of the Laytonville-Branscomb county road and the construction of 2.2 iles of access roads.

Recreation Facilities. As described in Appendix B, the potential for recreation development at Standley Reservoir would be very limited due to lack of developable lands. The initial installation of facilities would use all of the available lands, and these facilities would be used to capacity in the first decade of project life. Recreation costs would include the facilities costs developed in Appendix B, the cost of additional lands required for recreation development, and the cost of 2.2 miles of recreation access road.

Fish and Wildlife Preservation. Project costs for maintaining the fish and wildlife populations in the reservoir area were determined by the Department of Fish and Game. These costs consist of the development and maintenance of 230 acres of deer range for mitigation purposes.

Flood Control. The limited storage capacity and the headwaters location of the Standley Project combine to make its potential for flood control almost nonexistent. This purpose was not included in the formulation of the project.

Water Conservation. Project costs for water conservation were determined from the projected demand for water in Chapter 2 and the unit costs shown in Chapter 3. The capital cost for diverting and pumping the conservation yield from the Standley Project was estimated to be about $690,000. Approximately 10 percent of this amount would be the initial capital cost, with the balance coming as future expenditures.

Summary of Costs. A summary of the estimated project costs during the 100-year period of analysis is presented in Table 21. The initial capital outlay for this project is estimated to be $7,200.000. The present worth of the total expenditure during the period of analysis is estimated to be $9,500,000.

TABLE 21

SUMMARY OF STANDLEY PROJECT COSTS

Project Feature	Capital Cost	Operation, Maintenance, Replacement, and General Expense*	Present Worth of Total Expenditure Over 100 Years
Standley Dam, Reservoir, and Appurtenances	$5,800,000	$ 500,000	$6,300,000
Recreation Facilities	1,300,000	1,160,000	2,460,000
Fish and Wildlife Preservation	30,000	20,000	50,000
Water Conservation - Diversion and Pumping	70,000	620,000	690,000
TOTAL	$7,200,000	$2,300,000	$9,500,000

* Includes present worth of all future additions and expenditures.

Project Accomplishments and Benefits

The formulation of the Standley Project included the purposes of local water supply, recreation, and fish and wildlife preservation and enhancement. In the analysis of this project, several operation studies were made to define project yields and compare alternative sizes. Initially a much larger development was considered for this site (water surface elevation 1920 feet with a storage of 32,500 acre-feet). However the questionable foundation geology and potential leakage through the narrow ridge south of the dam limited the maximum size of the project to the scale as presented herein. The following sections describe the accomplishments of this smaller project and the associated benefits.

Local Water Supply. When operated as shown in Table 22, the Standley Project could maintain a minimum flow in the South Fork Eel River of 10 cfs. Of the firm annual release of 7,200 acre-feet, about 2,550 acre-feet would be released during the summer months of low supply and could be used for urban and recreation purposes in the Lake Benbow and Humboldt Redwoods subunits of the lower basin. This water supply would provide a capitalized benefit of $4,200,000.

Recreation. The Standley Project has a very limited potential for recreation development. The Department of Parks and Recreation has estimated that the developable lands around Standley Reservoir would support water-associated recreation use of up to 60,000 visitor-days per year. The recreation development would be used to capacity throughout the life of the project. Using the criteria described in Chapter 3, a value of $1.75 per visitor-day was determined for general recreation use at Standley Reservoir. By applying this value to the projected recreation use presented in Appendix B, a total capitalized benefit for general recreation use of $2,600,000 was determined. A portion of this benefit is credited to fishery enhancement in the following section. The total benefit for non-fishing general recreation use at the Standley Project would be about $1,800,000.

Fish and Wildlife Enhancement. The Department of Fish and Game determined that there is a significant potential for fishery enhancement at the Standley Project, but found that there is no potential for wildlife

TABLE 22

SUMMARY OF MONTHLY OPERATION STUDIES
OF STANDLEY RESERVOIR

16,500 Acre-Feet of Storage
(In Acre-Feet)

Runoff Year	Storage on October 1	Inflow	Annual Water Releases and Losses			
			Stream Maintenance 1/	Evaporation	Spill	Total
1913-14	9.3	26.6	7.2	.6	14.1	21.9
14-15	14.0	26.0	7.2	.6	18.4	26.2
1915-16	13.8	23.3	7.2	.6	15.2	23.0
16-17	14.1	14.5	7.2	.6	6.8	14.6
17-18	14.0	8.0	7.2	.6	.9	8.7
18-19	13.3	17.3	7.2	.6	9.2	17.0
19-20	13.6	5.0	7.2	.6	0	7.8
1920-21	10.8	24.6	7.2	.6	14.0	21.8
21-22	13.6	12.8	7.2	.6	4.7	12.5
22-23	13.9	9.5	7.2	.6	2.2	10.0
23-24	13.4	3.2	7.2	.6	0	7.8
24-25	8.8	23.0	7.2	.6	9.9	17.7
1925-26	14.1	11.4	7.2	.6	4.6	12.4
26-27	13.1	24.4	7.2	.6	15.9	23.7
27-28	13.8	15.5	7.2	.6	7.3	15.1
28-29	14.2	6.9	7.2	.6	0	7.8
29-30	13.3	11.9	7.2	.6	3.9	11.7
1930-31	13.5	5.9	7.2	.6	0	7.8
31-32	11.6	12.4	7.2	.6	2.2	10.0
32-33	14.0	12.6	7.2	.6	4.6	12.4
33-34	14.2	8.8	7.2	.6	1.7	9.5
34-35	13.5	16.6	7.2	.6	8.5	16.3
1935-36	13.8	18.5	7.2	.6	10.8	18.6
36-37	13.7	12.3	7.2	.6	4.1	11.9
37-38	14.2	32.8	7.2	.6	25.1	32.9
38-39	14.1	9.5	7.2	.6	2.8	10.6
39-40	13.0	22.7	7.2	.6	14.3	22.1
1940-41	13.6	25.3	7.2	.6	16.9	24.7
41-42	14.2	23.3	7.2	.6	15.0	22.8
42-43	14.7	18.3	7.2	.6	11.2	19.0
43-44	14.0	8.1	7.2	.6	.4	8.2
44-45	13.9	16.2	7.2	.6	8.2	16.0
1945-46	14.1	19.5	7.2	.6	12.4	20.2
46-47	13.4	12.0	7.2	.6	4.1	11.9
47-48	13.5	15.9	7.2	.6	7.0	14.8
48-49	14.6	15.1	7.2	.6	8.5	16.3
49-50	13.4	14.3	7.2	.6	6.2	14.0
1950-51	13.7	23.9	7.2	.6	16.4	24.2
51-52	13.4	24.7	7.2	.6	16.7	24.5
52-53	13.6	23.7	7.2	.6	14.7	22.5
53-54	14.8	22.4	7.2	.6	15.7	23.5
54-55	13.7	9.8	7.2	.6	1.7	9.5
1955-56	14.0	29.8	7.2	.6	22.9	30.7
56-57	13.1	16.1	7.2	.6	6.8	14.6
57-58	14.6	32.8	7.2	.6	26.0	33.8
58-59	13.6	12.1	7.2	.6	4.6	12.4
59-60	13.3	16.4	7.2	.6	7.6	15.4
1960-61	14.3	17.4	7.2	.6	9.7	17.5
61-62	14.2	11.6	7.2	.6	4.8	12.6
62-63	13.2	20.0	7.2	.6	11.5	19.3
63-64	13.9	13.0	7.2	.6	6.0	13.8
AVERAGE	13.5	16.9	7.2	.6	8.9	

1/ Constant release of 10 cubic feet per second. Streamflow will be greater in most winter months as the reservoir fills and overflows.

enhancement. The fishery enhancement is evaluated on the assumption that an adequate volume of water at a suitable temperature could be obtained from the reservoir.

Natural production of fish in Standley Reservoir could support 18,000 angler-days of use per year. Assuming that angler use of the reservoir would remain at 18,000 angler-days per year through the life of the project, a general recreation benefit for fishing would be provided that would have a capitalized value of about $800,000.

The maintenance of a minimum flow of 10 cfs in the South Fork Eel River below Standley Dam would enhance nursery areas for juvenile silver salmon and steelhead. This enhancement would increase the spawning population of silver salmon and steelhead by about 1,500 fish, the commercial catch by about 1,300 silver salmon, and the sport catch by about 550 silver salmon and steelhead and 9,000 trout. These increases would provide a capitalized benefit of about $400,000.

The Standley Project could not provide sufficient water to enhance spawning conditions in the river or to attract fish into the river before the fall rains. Hence, no benefits can be attributed to the project for these purposes.

Summary of Project Benefits. A summary of the estimated benefits for the Standley Project is presented in Table 23. The present worth of the total benefits is $7,221,000.

TABLE 23

SUMMARY OF STANDLEY PROJECT BENEFITS

Project Purpose	Present Worth of Total Benefits
Water Conservation	$4,200,000
Recreation	1,800,000
Fisheries Enhancement	1,200,000
TOTAL	$7,200,000

Economic Justification

The criterion used to measure the economic justification of a proposed water project is the ratio of benefits to costs. For a project to be economically justified, the primary tangible benefits must exceed the total project costs when compared over the same period of time.

The Standley Project, if constructed in 1975 and operated as shown in Table 22, would provide total benefits of $7,200,000 with a comparable total project cost of $9,500,000. The resulting benefit-cost ratio is 0.76 to 1.00. Therefore, the Standley Project is not economically justified.

Cost Revision

A detailed presentation of the project designs and cost estimates can be found in an office report, "South Fork Eel River Study - Designs and Cost Estimates", dated April 1967, which is on file in the Northern District office.

The office report was reviewed by the Staff Engineering Branch of the Department's Division of Design and Construction and revised in accordance with the Branch's comments where appropriate. The cost estimate for the Standley Project was not revised, since the preliminary analysis showed the project to be not economically justified and the suggested changes would increase the project costs. Therefore, the cost of Standley Dam, Reservoir, and Appurtenances, as shown in Table 21, is low, and the project would actually show a more unfavorable benefit-cost ratio than that described above.

Low Dams for Recreation

The South Fork Eel River Study included limited consideration of low temporary dams on the main South Fork for recreation purposes. This phase of the study considered the possibility of creating recreation pools at favorable locations along the river without interfering with the migration of anadromous fish.

FIGURE 12. TYPES OF LOW DAMS

DWR Photographs

BEAM AND FLASHBOARD DAM
(Russian River Recreation and Park District, Guerneville)

IMBERSTON FABRIDAM
(Photographs courtesy of the Firestone Coated Fabrics Company)

November 1966 June 1967 DWR Photographs

GRAVEL DAM
(Bell Glen Resort near Leggett)

Low dams of many types have been used at various locations in the North Coast area for many years to create summer recreation pools. Three of the more notable sites are the Healdsburg Community Park, the Russian River Recreation and Park District at Guerneville, and Benbow Lake State Recreation Area. Within the South Fork Basin, several resort owners have created recreation pools by building temporary dams of stream gravels. These gravel dams merit close examination since their total cost is usually less than the annual cost of operation on any permanent structure.

The first proposal for a formal study of low-level recreation dams was made at the public hearing on the Department of Resources' Bulletin No. 92, "Branscomb Project Investigation", in Willits in 1964. At that hearing, Mr. Otto von Seggern proposed an alternative to the Branscomb project - development of the tributary streams in the South Fork Basin and the development of low-level recreation pools at nine locations along the South Fork Eel River.

Within the South Fork Eel River Study, seven possible low-level recreation sites were inspected. These sites were Weott, Myers Flat, Miranda, Phillipsville, Garberville, Piercy, and Leggett. The Garberville and the Miranda sites were determined to be the most practical. Plane-table topographic surveys of these two reservoir areas were made in the summer of 1966.

Four types of dams were considered for impounding recreation pools on the South Fork Eel River. These four types are concrete weirs, beam and flashboard, the Firestone Fabridam, and gravel dams (see Figure 12).

Concrete overflow dams, similar to the existing Benbow Dam, were considered briefly in this study and rejected as impractical. Sediments carried by high flows in the South Fork would fill the reservoir, probably in a few years. The natural reservoir of the existing Benbow Dam is completely filled with sediment, making it necessary to supplement the dam with an 11-foot board and beam superstructure to impound a recreation pool. It would be unwise to create a similar situation at another location on the South Fork Eel River.

Several different designs of flashboard-type, low-level dams were inspected for this study. The most practical installation appears

to be a permanent-beam installation with removable flashboards. Experience with collapsible structures, such as hinged beams, has indicated that these structures are subject to high operation and installation costs. The Russian River Recreation and Park District has indicated that their experience with a flashboard dam of the type illustrated shows that it is operable and has low operation and installation costs.

Another type of low-level dam that may be very practical for use in the South Fork Eel River is the Imbertson Fabridam made by the Firestone Coated Fabrics Company. However, this structure may be somewhat more expensive than the other types discussed. The Firestone Company has frequently demonstrated its willingness to participate in planning efforts on low-level dam installations.

The flashboard dams and Fabridams are permanent installations that have several advantages and disadvantages. As permanent structural units, they may possibly be financed with state or federal assistance. They will require an annual expenditure for operation and maintenance and have a limited lifetime -- about 5 years for the timber portion of flashboard structures and about 20 years for the Imbertson Fabridam. Also, they may require substantial expenditures for foundation construction. Any foundation structure in the South Fork Eel River channel must be designed and constructed to withstand substantial flood flows. Preliminary studies have shown that foundation costs alone may range from $100,000 to $500,000 for any single installation.

A more practical approach to the creation of recreation pools in the South Fork Eel River may be that used by several resort owners along the stream at present - the casual construction of crude gravel dams across the river that remain only until the first high flows in the fall sluice them away. These gravel dams have several distinct advantages for the South Fork Basin. They are extremely inexpensive. The gravel dam illustrated in Figure 12 was installed in 1966 for less than $300. Preliminary studies have shown that gravel dams are almost maintenance free, require no operation, and can be installed for less than the annual operation and maintenance costs of most permanent installations. They are natural in appearance and can be used for roadways for low-water crossings. Also, they can be of distinct advantage to water quality in the river

since they act as natural sand-gravel filters for part of the flow. Gravel dams can be built at the most desirable location each year and do not represent a permanent capital investment. However, these temporary structures have one overriding fault. It is doubtful that state or federal contributions could be made to the development of a recreation area around a recreation pool that is not permanent.

The pools created by low-level dams within the South Fork may be of substantial benefit to the anadromous fishery, particularly silver salmon and steelhead. There is insufficient data to reach definite conclusions, but studies by the Department of Fish and Game have indicated that maximum water temperatures at the lower levels of these pools will remain 6° to 10° lower than in the natural stream channel. This would tend to alleviate one of the major problems of anadromous fish in the South Fork Basin, as cited in Appendix C, namely water temperatures in the summer months that are occasionally too high for juvenile salmon and trout.

Since the South Fork Eel River Study focused on major reservoir developments on tributary streams, the low-level recreation dam study was limited in scope. Any detailed studies of low-level recreation dams would most logically be initiated by the local community directly affected by a proposed project. The Department of Parks and Recreation believes that these structures should occupy an important position in future planning in the South Fork Eel River Basin. The Department of Water Resources recommends, in Chapter 1 of this report, that interested local communities initiate studies of this type of development. This Department could provide advice to communities on these studies.

CHAPTER 5. PROJECT IMPLEMENTATION

The usual steps in water project implementation are reconnaissance studies, feasibility studies, authorization, final design, and construction. Chapters 1 through 4 of this report have presented the results of a reconnaissance study. This chapter discusses the activities involved in conducting feasibility studies and attaining project authorization.

Feasibility Studies

For a project to be considered feasible for development it must generally possess the three following qualifications: (1) engineering feasibility, (2) economic justification, and (3) financial feasibility. In general terms a project is considered to possess engineering feasibility if it can be constructed safely by accepted techniques at a reasonable cost. While engineering feasibility has been determined to reconnaissance standards at the sites selected in this report, additional geologic exploration and detailed designs would be needed to bring this determination up to feasibility study standards.

Economic justification requires that the estimated benefits exceed the corresponding costs of the project. Refined benefit and cost estimates should be completed to feasibility standards to demonstrate economic justification to the extent necessary for project authorization.

A project is considered to be financially feasible if funds for construction and operation of the project are available, and further, that reimbursable items can be repaid from the project revenues at the stipulated interest rate. One of the first steps in determining financial feasibility is the preparation of refined cost estimates. These estimates are needed to insure that funds authorized will be sufficient to complete project construction. Another vital step in determining financial feasibility is to allocate the total project cost among the various purposes served by the project. Preparation of refined cost allocations is one of the major purposes of feasibility studies and requires much more advanced data than are normally available in a reconnaissance-level study. A cost allocation

identifies the reimbursable and the non-reimbursable project costs and thereby provides insight into the most logical methods of project financing and authorization.

It is not within the scope of this report and it is not possible at this time to show all possible means of financing the projects. However, the most obvious possible sources are pointed out to aid the agency that undertakes feasibility level studies of the projects.

Funds for the construction of the projects described in this report could come from a variety of sources. Among these are (1) state financial assistance for a project constructed by a local agency through grants and loans under provisions of the Davis-Grunsky Act, (2) state financing through special legislation, (3) federal financing through grants and loans, (4) local financing through the sale of bonds, (5) state financing as a facility of the State Water Resources Development System, or (6) a combination of these alternatives.

In addition to evaluating potential sources of financing, a feasibility-level study of the Cahto Project, the more favorable project for initial development, should include the following:

1. Detailed geologic exploration based on the recommendations for further study in the office report "Engineering Geology of Damsites - South Fork Eel River Study".

2. A routing study of the required relocation of Highway 101 by the Division of Highways. This study is estimated to require 13 months and about $30,000 to complete.

3. Evaluation of the potential savings to be realized from joint construction of the Cahto Project and the planned improvement of Highway 101 to freeway standards. Realization of this potential would require that authorization and final design of the Cahto Project be completed by about 1975.

4. Refined evaluation of the water supply function of the project, particularly with regard to the specific areas to be served.

5. Refined evaluation of the recreation and fishery enhancement potentials of the project, including a water temperature study as recommended by the Department of Fish and Game.

6. Detailed analysis of the flood control capabilities of the project.

7. Stream sampling and detailed sample interpretation to define the water quality aspects of the project.

Authorization

It would be possible that the projects described in this report could be authorized as features of the California Water Resources Development System. However, no financing is available in the current funding under the Burns-Porter Act for features other than those currently authorized as a part of the State Water Project. Since the Cahto and Panther Projects can meet local needs in conjunction with the development of major projects on the upper Eel River, authorization under the California Water Resources Development System may in the future be an appropriate means of advancing these projects.

An agency in the lower South Fork Basin or the Eel River Delta desiring additional firm water supply could finance and construct projects in the South Fork Basin. However, the agency would have to reevaluate these projects to reflect its own needs and plans.

Another possibility would be through authorization by the Legislature of a grant and loan under the Davis-Grunsky Act. However, before such a grant or loan could be made, it would be necessary to complete a feasibility study of the project under consideration.

For any project, and for any method of project implementation pursued, local initiative and action will be needed to move a project towards construction. The first step in project implementation for any local area is the dissemination of knowledge of promising local developments. This report has been prepared to help provide that knowledge.

Appendix A

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Appendix B

RECREATION

By

Department of Parks and Recreation

NOTE

This appendix is a reproduction of the South Fork Eel River recreation report prepared and distributed by the Department of Parks and Recreation, except that two project names have been changed. After the recreation report was completed, interested local agencies requested that the Spring Creek project be named Cahto and that the original Cahto project be named Standley. This appendix reflects these changes.

State of California — The Resources Agency of Californi

Memorandum

To : Honorable William R. Gianelli, Director
Department of Water Resources
Resources Building, 11th Floor
Sacramento, California

Date : April 26, 1967

Subject: Transmittal of Report,
South Fork Eel River Recreatio
Reconnaissance Report

From : **Department of Parks and Recreation**

I am pleased to transmit the subject report, which has been prepared for the Department of Water Resources, Northern District, by our Recreation Contract Services Unit under the provisions of Interagency Agreement No. 255049.

The purpose of this study was to assist the Department of Water Resources in locating and identifying potential water development projects which could be constructed for local water supply, flood control, recreation, and fisheries enhancement purposes in the South Fork Eel River basin. This report defines locations where reservoir development enhances the recreation potential of the study area.

We conclude that reservoirs in the South Fork Eel River hydrographic area, if properly located, constructed and operated, could provide increased opportunity for a variety of recreation pursuits, assist in the maintenance and enhancement of a fisheries resource, and supplement local economies.

It is emphasized that the recreation planning criteria used in the development of cost and use estimates were based upon stable recreation pools at the specific elevations indicated in the subject report. These evaluations are based on optimum development of the land and water surface areas available at those elevations. Major changes in reservoir operation criteria could have an adverse effect on predicted use figures, recreation benefit values, and recreation costs.

William Penn Mott, Jr.
Director

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State of California
The Resources Agency
DEPARTMENT OF PARKS AND RECREATION
Division of Beaches and Parks
Recreation Contract Services Unit

This report was prepared for the Department of Water Resources, Northern District, under the terms of Interagency Agreement No. 255049

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SUMMARY

Early engineering studies of the South Fork Eel River by the Department of Water Resources included the Branscomb Project Investigation and the Lower Lake Benbow Recreational Project, South Fork Eel River. Both of these project proposals experienced considerable opposition because of their limited concepts and the adverse effect upon fishery resources. Present studies are devoted to the concept of a multi-purpose basin plan, which would assure maximum utilization of all potential water resource developments within the South Fork Eel River Basin.

Since transmittal of the Progress Report, Recreation Reconnaissance, South Fork Eel River, in June of 1966, the number of possible reservoir sites has been further reduced by engineering, geological, and recreation evaluations. The present priority is summarized in Table 1. Table 1 also provides a quick analysis of the recreation potential exhibited at each reservoir proposal. The location and engineering features of each reservoir proposal are designated in Table 2.

Early in the development of our study program it was recognized that geology would be one of the foremost problems in the selection of specific damsites because of the prevalence of the Franciscan Formation in the South Fork Eel River Basin.

Other program needs emerged during this study which should be investigated in greater detail. The possibility of providing "low level" summer season reservoir pools and recreation facilities on the South Fork Eel for local community use and development has evolved into an important study requirement. These river recreation pools would be constructed near communities which could provide the services, the staffing, and the equipment necessary to maintain the pools for the visiting public.

TABLE 1. Summary of Reservoir Recreation Potential
South Fork Eel River

Damsite	Developable Lands	Access	Esthetics	Reservoir Sizing	Recreation Potential
Tenmile Creek					
1. Cahto[1]	F	G	G	G	G
2. Streeter[1]	G	G	G	G	G
3. Stapp[1]	G	G	G	F	G
East Branch - South Fork Eel					
4. Panther[2]	P	P	G	P	P
South Fork Eel					
5. Standley[3]	P	P	F	P	P

G = Good F = Fair P = Poor

1/ Evaluations for these reservoirs were based upon a normal pool elevation of 1,580 feet mean sea level.
2/ Evaluated at a normal pool elevation of 500 feet M.S.L.
3/ Evaluated at a normal pool elevation of 1,900 feet M.S.L.

TABLE 2. Summary of Reservoir Study Locations and Features

Reservoir Damsite	Location	Stream	Features: Drainage Area (square miles)	Streambed Elevation (feet)	Maximum Dam Height (feet)	Normal Water Surface Elevation (feet)	Water Surface Area At Normal Pool (acres)	Gross Storage At Normal Pool (acre-feet)
Stapp	Mendocino Co. near Laytonville NW¼26, T22N, R15W, MDB&M Branscomb Quad. 15' Series 50 ft. contours	Tenmile Creek	34.9	1,490	118	1,580	710	28,100
Streeter	Mendocino Co. near Laytonville NE¼21, T22N, R15W, MDB&M Leggett Quad. 15' Series 100 ft. contours	Tenmile Creek	46.1	1,440	170	1,580	1,510	80,500
Cahto	Mendocino Co. near Laytonville NW¼16, T22N, R15W, MDB&M Leggett Quad. 15' Series 100 ft. contours	Tenmile Creek	50.3	1,425	178	1,580	1,750	95,500
Standley	Mendocino Co. near Laytonville SW¼33, T21N, R15W, MDB&M Branscomb Quad. 15' Series 50 ft. contours	South Fork Eel River	7.1	1,740	160	1,880	320	16,500
Panther	Humboldt County near Benbow SRA NE¼31, T4S, R4E, Humboldt Base Garberville Quad. 15' Series 100 ft. contours	East Branch South Fork Eel River	74.8	390	230	600	920	80,200

Conclusions and Recommendations

Reservoir development in the South Fork Eel River hydrographic area could provide increased opportunities for a variety of recreational pursuits, assist in the maintenance and enhancement of a basic fishery resource, and supplement local economies.

Of all reservoir sites considered, those on Tenmile Creek exhibit the best recreation possibilities primarily because of favorable terrain, sizing, and access.

Further reconnaissance studies should be conducted to evaluate the potentials of low-level, semi-permanent reservoirs located on the South Fork Eel River.

Modification of Benbow Dam might significantly increase the recreation potential of Benbow Lake State Recreation Area.

Panther damsite has a lesser recreation potential than modification of Benbow Dam.

The recreation potential of Standley Reservoir site is minimal.

It is recommended that the Department of Water Resources consider Tenmile Creek for large reservoir development. For recreation purposes a stable pool elevation of 1,580 feet would be desirable.

It is recommended that the Department of Water Resources initiate studies of low-level, semi-permanent, seasonal reservoir impoundments.

It is recommended that Panther Reservoir site be considered for recreational purposes only if Benbow Dam is not adaptable to improvement.

It is recommended that the Department of Water Resources reject the Standley site for recreation purposes.

It is suggested that the Department of Water Resources assist local communities in the South Fork Eel River Basin in the formation of special districts. Davis-Grunsky funds and technical assistance would be more readily available to communities forming water and recreation districts with taxing privileges.

INTRODUCTION

As part of Department of Water Resources' planning for the north coastal area of California, recreation planning for the South Fork of the Eel River was initiated on July 19, 1965. A progress report of the work accomplished was prepared and forwarded to the Department of Water Resources in June 1966. Since then, project study areas have been refined and additional cost estimates prepared. With the submission of this report, present budgeted recreation reconnaissance studies for the South Fork Eel River will be concluded.

The general purpose of the reconnaissance was to assist in the location and identification of potential water development projects which might be constructed for purposes of local water supply, flood control, and recreation and fisheries enhancement. The specific purpose of this report is to define locations where reservoir development has definite recreation potential in the South Fork Eel River hydrographic subunits.

The recreation planning evaluations presented in this report assume stable recreation pools. Major changes in pool elevation criteria could have an adverse effect on predicted use figures.

Planning efforts were carried on under Work Authority No. 1250.

OREGON
NORTH
COASTAL
RIVER
BASIN
SACRAMENTO
NORTH
LAHONTAN
SAN
FRANCISCO
BAY
SAN
JOAQUIN
RIVER
BASIN
TULARE
LAKE
CENTRAL
COASTAL
BASIN
SOUTH
COASTAL
COLORADO
DESERT
IMPERIAL
MEXICO
PACIFIC
OCEAN
NEVADA
SOUTHLAHONTAN
MAJOR HYDROGRAPHIC AREAS
OF CALIFORNIA

SOUTH FORK EEL RIVER HYDROGRAPHIC SUBUNITS
WITHIN THE
EEL RIVER HYDROGRAPHIC UNIT

STATE OF CALIFORNIA
THE RESOURCES AGENCY
DIVISION OF BEACHES AND PARKS
DEPARTMENT OF PARKS AND RECREATION

—•—

SOUTH FORK EEL RIVER AREA OF INVESTIGATION

RECREATION ANALYSIS

Location

The Eel River Hydrographic Unit is within the North Coast Hydrographic Area, one of seven major areas within California as defined by the Department of Water Resources. Extending nearly 140 miles in a northwest-southeast direction from Humboldt Bay to the mountains of northern Lake County, it is composed mainly of the watersheds of a number of lesser streams. The hydrographic subunits of Humboldt Redwoods, Lake Benbow and Laytonville, within Mendocino and Humboldt counties, contain the essential elements of the drainage of the South Fork Eel River with which this study is concerned. This study area is shown on Plate 1.

Early engineering studies have located 24 potential reservoir sites in the hydrographic subunits of the South Fork Eel River. Two published reports have been produced by the Department of Water Resources: Bulletin No. 92, The Branscomb Project Investigation, February 1965; and The Lower Lake Benbow Recreational Project, South Fork Eel River, November 1964. Both of these project proposals experienced considerable opposition from the Department of Fish and Game because of the adverse effect upon anadromous fish utilizing spawning areas located in the upper reaches of the South Fork Eel and tributary streams.

One of the participants at the public hearings on Bulletin 92, Mr. Otto C. von Seggern, private consulting engineer, proposed a multi-purpose basin plan. The plan would include headwater reservoirs on main tributaries to the South Fork Eel River to provide streamflow regulation, recreation, and domestic water. Low level check dams and recreation pools would also be provided at selected sites on the South Fork Eel River. These would be constructed as needed near state parks and local communities.

Mr. von Seggern believed that more benefits would accrue from a multi-purpose basin plan with provisions to ensure the enhancement of fish and wildlife, ensure recreational use, provide higher land utilization, and assure dependable water supplies. The alignment of our present study has closely paralleled the suggestions offered by Mr. von Seggern.

Topography and Geology

The study area is characterized by rough, steep stream-dissected terrain with a few inland valleys. There are numerous landslides which are attributed to the Franciscan Formation and the high annual rainfall.

Several ground water basins have been formed as a result of downfaulting of large blocks and partial filling of the resultant depression with alluvium and lake deposits. Laytonville Valley is one of three significant valleys in the Eel River Hydrographic Unit formed in this manner and is the major ground water basin within the South Fork Eel Basin.

Climate

Generally, more severe seasonal climatic variations are experienced in the inland valleys somewhat removed from the moderating influence of the moist air mass dominating the immediate coastal areas. Average temperatures range from 45° Fahrenheit in January to 72.5° in July. Average annual rainfall patterns extend from 35 inches to 81 inches. Occasional snowfall occurs increasing in depth and frequency at the higher elevations.

Vegetative Cover

Forest lands, including "cut over", and range lands account for 98 percent of the total study area. The forest cover is composed primarily of redwood, Douglas fir, tanoak, madrone, and California laurel. Various ground covers such as oxalis and wild strawberry are frequently interspersed with woodwardia and sword ferns, and add to the esthetic quality of forested areas. In the Laytonville area the climate is drier and pine and oak species are found more frequently. The Laytonville valley is open grassland with scattered oak trees.

Access

Automotive access to the study area is provided by the Redwood Highway, U. S. 101, the main north-south route in the coastal area. East-west travel is provided by State Highway 36 and U. S. Highway 299. Both link the hydrographic subunits with the Sacramento Valley.

Small airports are located at Laytonville and Garberville.

Despite the importance of U. S. Highway 101 to people traveling to the South Fork Eel and the redwoods, access via this route has been historically difficult. This has probably contributed to the short visitor use season experienced in the area. To alleviate travel difficulties, the California Division of Highways is pushing ahead with planning and construction efforts to improve road conditions into the South Fork Eel River area. The relative remoteness of the area will diminish as Highway 101, the area's principal artery, becomes a 4-lane freeway.

Economics

The total Eel River Hydrographic Unit has an estimated 1,525,000 acres of timberland containing 38.2 billion board feet of commercial timber, more timber than is found in any other unit of the north coastal area. Lumbering and associated industries rank first in economic importance within Humboldt and Mendocino counties. More than one-half the payroll in Mendocino County is derived from lumbering and wood products industries. Recreational resources are second in economic importance in Humboldt County and third in Mendocino County. The largest segment of recreational activities occur in the redwood state parks, although the economic impact is focused in the metropolitan areas. State parks and reserves in Mendocino and Humboldt counties include 24 state park parcels containing 57,819.59 acres of land. These units reported 1,809,324 annual visitors in 1963-64.

Several related economic problems are working in concert to change the pristine character of the north coast.

First, north coast counties will face major transformations in economic structures within a decade as a result of the depletion of primary timber resources. As forestry changes to a sustained yield operation and a stable level of employment, recreation and tourism will offer a viable basis for economic growth without further depletion of basic natural resources and will assume a more dominant position in the economic base of these counties.

Second, a considerable decline in agricultural products is anticipated by county planners.

Third, the remoteness of the area will diminish as Highway 101 becomes a 4-lane freeway. Driving time from major population centers will be shortened and driving hazards reduced.

Fourth, properly planned reservoir development should provide increased opportunities for longer recreation visits in the redwood country as well as assist in the maintenance and enhancement of a basic fishery resource.

State and Federal Parks

The South Fork Eel River drainage encompasses some of the most favored and famous state park areas in the State. The chief attraction is the stately groves of California coast redwood trees. One of the primary roles of the State Park System has been to preserve and perpetuate representative examples of the redwood forest country for future generations of Californians.

In Humboldt County there are 11 state parks and reserves comprising some 51,209.43 acres of land. These holdings range from 11.78 acres at Fort Humboldt State Historical Monument to 38,246 acres at Humboldt Redwood State Park. There are 7 operating state parks within Humboldt County with a reported annual attendance of 1,239,733 visitors in fiscal year 1963-64.1/

In Mendocino County there are 13 parcels comprising some 6,610.16 acres of state park lands and reserves. These lands range from 11.81 acres at Paul M. Dimmick State Recreation Area to 1,824.94 acres at Van Damme State Park.2/

Table 3 summarizes visitor attendance, revenue and operational costs for those units operating within the South Fork Eel hydrographic subunits. Plate 2 shows the location and approximate size of these units.

National interest in the north coast redwoods is expressed by proposals before the Congress of the United States for the establishment

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1/ Source: Public Land Ownership and Use in California. Senate Permanent Fact Finding Committee on Natural Resources, Third Progress Report to the Legislature, 1965 Regular Session, page 134.

2/ Ibid.

NOTE: Reynolds Redwood Flat project consisting of 375.80 acres was acquired on June 23, 1966. At Van Damme 1.54 acres of surplus property was transferred for disposal. These property transactions bring the Beaches and Parks total in Mendocino County to 14 parcels and 6,984.42 acres.

TABLE 3. Operating State Park Units[1]
Reported Attendance, Revenue and
Operating Expenses[2]

Unit	Fiscal Year 1961-62	1962-63	1963-64[5]	1964-65	1965-66[6]
STANDISH-HICKEY S.R.A.[3]					
Attendance	73,766	76,603	83,012	78,517	69,831
Revenue	$14,730	$ 14,583	$ 16,896	$ 27,299	$ 25,726
Operating Costs		$ 39,469	$ 45,314	$ 46,730	$ 47,544
RICHARDSON GROVE S.P.					
Attendance	476,535	491,215	471,670	481,530	455,444
Revenue	$31,852	$ 36,416	$ 38,036	$ 41,097	$ 55,166
Operating Costs		$ 78,401	$ 79,444	$ 84,585	$ 81,237
BENBOW LAKE S.R.A.[4]					
Attendance	26,794	49,064	59,086	40,675	38,485
Revenue	$ 2,530	$ 5,075	$ 5,859	$ 5,909	$ 3,020
Operating Costs		$ 15,606	$ 17,097	$ 17,150	$ 17,007
HUMBOLDT REDWOODS S.P.					
Attendance	1,964,128	2,047,339	379,057	472,170	431,827
Revenue	$18,663	$ 19,803	$ 23,424	$ 38,008	$ 32,312
Operating Costs		$146,078	$173,590	$183,789	$214,113

1/ All located on South Fork Eel River and Highway 101.

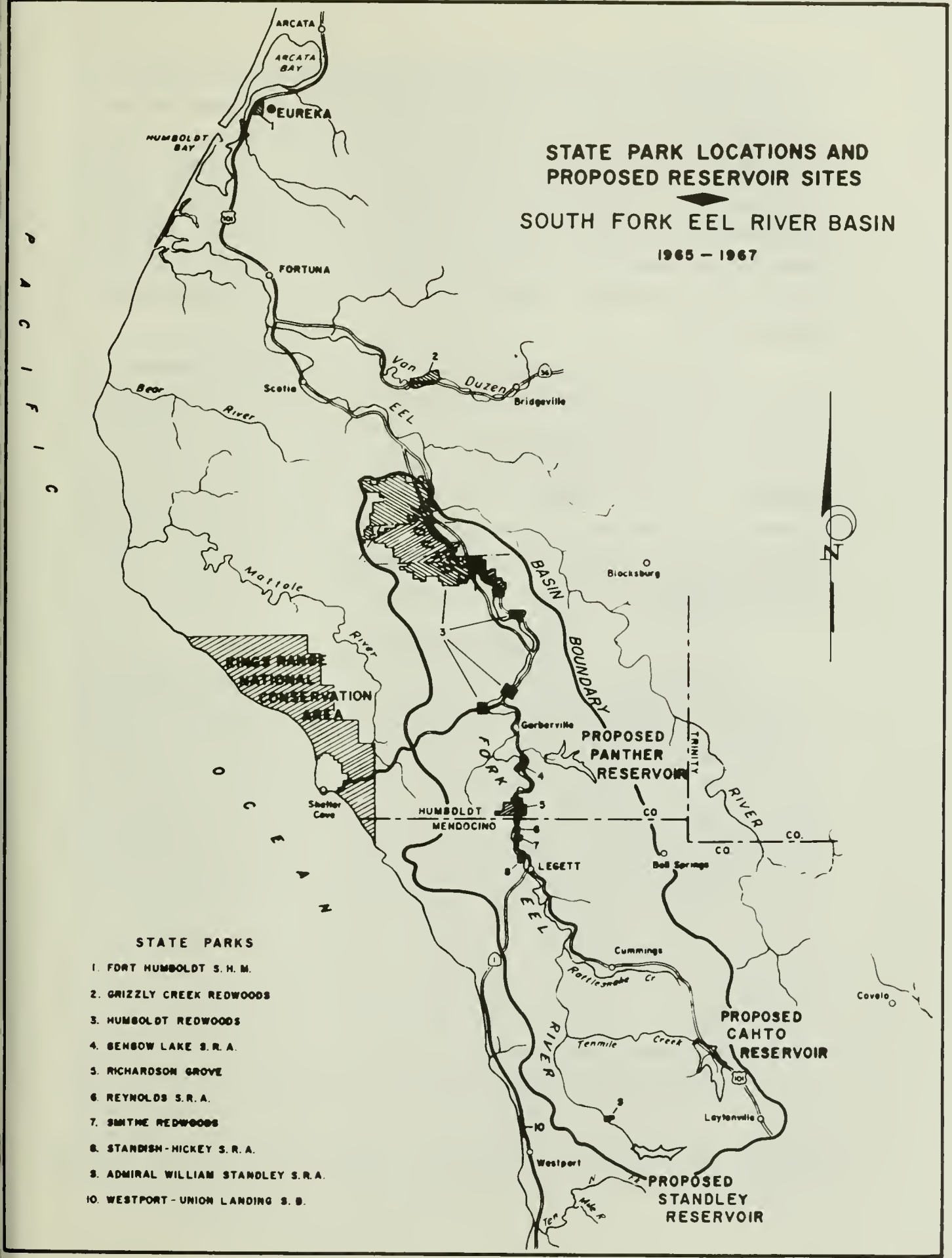
2/ Source: Annual Reports, Division of Beaches and Parks.

3/ Access to River exceedingly difficult.

4/ Day use area only.

5/ Camping fees at Standish-Hickey, Richardson Grove, and Humboldt Redwoods were increased from $1.00 per night to $2.00 per night effective January 1, 1964.

6/ Park administrators indicate that the drop in attendance in these parks can be attributed in part to three main factors: (1) the report of park damage arising from the floods of winter 1964-65; (2) the changes in Highway 101 alignment; and (3) a change in attendance reporting procedures.


STATE PARK LOCATIONS AND
PROPOSED RESERVOIR SITES
SOUTH FORK EEL RIVER BASIN
1965 – 1967
ARCATA
ARCATA BAY
EUREKA
HUMBOLDT BAY
FORTUNA
Scotia
Bear River
Van Duzen
Bridgeville
EEL
Mattole River
KINGS RANGE NATIONAL CONSERVATION AREA
Shelter Cove
Blocksburg
BASIN BOUNDARY
Garberville
FORK
PROPOSED PANTHER RESERVOIR
TRINITY
RIVER
HUMBOLDT
MENDOCINO
CO
CO.
LEGETT
Bell Springs
EEL
RIVER
Cummings
Rattlesnake Cr
Tenmile Creek
PROPOSED CAHTO RESERVOIR
Laytonville
Covelo
Westport
PROPOSED STANDLEY RESERVOIR
PACIFIC
OCEAN
N
STATE PARKS
1. FORT HUMBOLDT S. H. M.
2. GRIZZLY CREEK REDWOODS
3. HUMBOLDT REDWOODS
4. BENBOW LAKE S. R. A.
5. RICHARDSON GROVE
6. REYNOLDS S. R. A.
7. SMITHE REDWOODS
8. STANDISH-HICKEY S. R. A.
9. ADMIRAL WILLIAM STANDLEY S. R. A.
10. WESTPORT-UNION LANDING S. B.

of a redwood national park. Some of these proposals are the culmination of many years of planning effort and recognition of the unique ecology of the redwood forest environment of the north coast of California. Because of the tremendous economic importance of this resource, however, national park proposals have experienced considerable opposition from the lumber industry and some local residents. Most of the opposition has come from groups who are immediately affected and who fail to recognize the ultimate benefits which will accrue from the establishment of a national park in the north coast.

Emphasis for the establishment of a national park has been placed in the Redwood Creek and Mill Creek areas. These locations are considerably north of the hydrographic areas with which this study is concerned, but the establishment of a redwoods national park could substantially increase the number of people traveling through the study area. National park status would attract more people from outside of the State. Increased travel resulting from establishment of a national park could considerably alter projections of recreation use.

Recreation Potentials

The Park and Recreation Information System (PARIS), Department of Parks and Recreation Planning Monograph No. 2, November 1966, indicates South Fork Eel River recreation facilities are beyond four-hour travel zones for the major metropolitan areas of Northern California. These population centers represent the prime source from which projected recreation demand was computed for the South Fork Eel River. In these travel zones, PARIS shows projected deficiencies exist for camp units, picnic tables, boat access, parking space, marina slips and mooring.

These deficiencies are substantiated by a cursory examination of attendance records at park units within the South Fork Eel River hydrographic areas. Camping facilities, especially, are in short supply.

There were 3,505 small boat registrations in Humboldt County and 1,515 small boat registrations in Mendocino County as of June 1966.[3/] This does not include boats not required to be documented and boats used

3/ Source: Mr. DeBenedetti, Supervisor of Boating Registrations, Department of Harbors and Watercraft, Sacramento, California.

for commercial purposes. Based upon 1960 populations, these counties ranked 26th and 14th, respectively, in small boat registrations per capita throughout the State. Small boat owners have few areas available for water skiing and related water-associated activities in the north coast. During the summer, weather on the north coast is frequently foggy and cold, and many small boat owners will travel considerable distances to inland areas to search for warm water and for reservoirs large enough to safely support family boating activities.

Changing factors exist in the South Fork Eel River study area which make an evaluation of recreation potential somewhat nebulous. Foremost of these factors is the California Freeway and Expressway System being developed by the Division of Highways. Another is the developing economic situation. Unknown changes that may occur with or without the establishment of a redwood national park add to the complexity of recreation predictions.

The California Freeway and Expressway System is pushing forward with construction and planning efforts to improve road conditions into the South Fork Eel service area. These efforts will undoubtedly improve access to recreational areas. However, even highly desirable state parks along Highway 101 presently report use that is akin to overnight stop-overs for transient travelers. There is the very real possibility that better highways will enable travelers to reach their destinations in shorter driving time with less fatigue. The necessity for overnight stops in the redwood parks would be reduced. Already park administrators estimate approximately 80 percent of the reported visitation in north coat redwood parks represents sightseeing activities. At least three north coast state parks--Prairie Creek, Patrick's Point and Humboldt Redwoods--have experienced substantial declines in attendance over the past four years.

Richardson Grove State Park has easy access, camping, picnicking, swimming, naturalist and camp fire programs. Coupled with outstanding scenic and esthetic qualities, these attributes should contribute to an outstanding quality recreational experience for the park visitor. Yet, Table 4 shows that most campers at Richardson Grove State Park stay two days or less.

Table 4. Average Length of Stay
Campers at Richardson Grove State Park[1/]
1964 Season

Length of Stay (Days)	Percent of Monthly Camp Registrations			
	June	July	August	September
1	72.2%	47.9%	36.8%	64.9%
2	14.7	21.1	18.2	19.6
3	6.0	9.6	13.2	6.4
4	1.9	5.2	8.0	2.2
5	2.1	4.0	5.8	2.0
6	1.1	3.1	4.6	0.67
7	1.0	2.8	4.3	0.6
8	0.3	1.7	2.4	0.37
9	0.2	1.4	1.6	0.22
10	0.2	0.7	1.3	0
11	0.05	0.6	0.7	0
12	0.1	0.5	0.6	0.07
13	0.05	0.5	0.8	0
14	0	0.5	0.9	0.07
15	0.1	0.4	0.8	0

1/ Source: Administrative records for all registered campers, Richardson Grove State Park. Courtesy: Mr. Metcalf, Park Supervisor.

Recreation surveys at water-associated recreation areas in California show the length of stay averages from 3.6 to 4.6 days. Economic surveys indicate that longer periods of occupancy in recreation areas are equated with greater economic benefit to local communities serving the recreation visitor.

Boat ownership is closely associated with family income. Sophisticated boating equipment usually indicates higher recreation expenditures to support the equipment and desires of the boat owner.

It is logical to assume that greater economic benefits would accrue to the local community with the development of water-associated recreation areas.

A 1960 study showed four park units of the California Division of Beaches and Parks located adjacent to artificial lakes accounted for 11.4 percent of the gross reported recreation use in the State Park System. This dependence upon water-associated recreation in California

has been strengthened by other studies. The California Public Outdoor Recreation Plan indicated 60 percent of all recreation use in California is water associated.

With a few notable exceptions, the development of recreational facilities utilizing the appeal of the South Fork Eel River has not occurred. Surveys show where facilities are provided on the river, and quality operational and maintenance standards pursued, relatively heavy use will occur.

If increased recreation benefits are to be extended to the local business community some attraction other than the simple esthetic appreciation of redwood groves must be offered. This is not to say that the value of the redwood experience is reduced; but merely, in today's changing world, that youthful families are seeking more opportunities for active recreational pursuits. Water-associated activities offer an outlet for the expression of these desires.

From the point of view of preservation a secondary benefit is derived from the concentration of heavy visitor use in areas planned and selected as best able to support that use without damage to the basic resource. Unnecessary recreation use loads are lifted from sensitive park areas which are being preserved and perpetuated in their delicate and pristine glory for generations of future Americans.

Benbow Lake State Recreation Area

Benbow Lake State Recreation Area is ideally situated on the South Fork Eel River and U. S. Highway 101. The easy access from Highway 101, the travel distance from north and south metropolitan centers and the esthetic quality of the location place the park in a unique position. Because of the low quality of the temporary recreation facilities, however, the park unit is not fully utilized in satisfying the need for water-associated recreation in the South Fork Eel River Basin. The park is comprised of 222.91 acres of land acquired in 1958.[4/] A portion of the park lands to the south will be taken for new freeway alignments. The Division of Beaches and Parks intends to acquire additional lands to replace these losses. Additional facilities including campsite developments will be placed on these newly acquired lands.

4/ Source: Property Ownership Report, Division of Beaches and Parks, January 1, 1966.

A slab and buttress type dam built in 1932 across the South Fork Eel River is topped with 11 feet of temporary board superstructure during the recreation season to store a water surface area of approximately 123 acres at Benbow Lake State Recreation Area.

The nature of the dam structure presents several problems. The dam apparently has an adverse effect upon anadromous fish and the Department of Fish and Game is opposed to structures across the main river. Damage to park facilities and sediment deposition by flood waters is a recurrent problem. Each year there is a physical hazard to personnel placing the heavy steel beams and wood timbers of the headboard.

If these problems could be solved, it would greatly enhance the recreation potential at this park unit.

During the summer season a river and lake shoreline of some 15,650 linear feet at Benbow Lake State Recreation Area provides an attractive setting for tourists and recreation seekers using U. S. Highway 101. Much of the 123-acre reservoir surface is not available to power boating use because of a designated swimming area, shallow waters, and areas reserved for maintenance and operational purposes. Because of the limited water area available for power boats, park administrators have set safety limits of not more than 15 power boats to be operated on the lake at any one time.

About 35 percent of the summer use at this park represents enroute travelers, stopping for a brief respite. Recent surveys at Benbow Lake showed people within Humboldt and Mendocino counties were willing to travel up to 75 miles from their homes in order to use the limited day use and boating facilities provided at the park. At least 20 percent of the total use represented local residents traveling over 10 miles. See Table 5.

TABLE 5. Summary of Visitor Origin Survey
At Benbow Lake State Recreation Area[1/]
August 1966

Type of Origin	Percent of Vehicles Surveyed
Local Residents	
Less than 10 miles away	9
More than 10 miles away	20
Enroute	35
Staying in Area	
With friends or relatives	6
In a state park	13
In a motel	9
In a private campground	6
In a private trailer park	2
Total	100
California	86
Out of State	14
Total	100

1/ Source: Special Surveys, Recreation Data Coordinator, Recreation Contract Services Unit.

RECREATION DEMAND ESTIMATES

Recreation demand estimates for reservoir proposals in the South Fork Eel River hydrographic subunits were based upon California population statistics derived from the census of 1960. Existing population was determined in 50-mile increments up to a distance of 450 miles from each reservoir site. The balance of the state population was then grouped as one figure. Use potentials from out of state were ignored because an effective method to evaluate such use is not readily available. Statistics derived from surveys reveal about 14 to 20 percent of visitation in established state park areas represents out-of-state travelers. Future increase in out-of-state travel into the South Fork Eel River Basin may necessitate revisions in demand estimates for project study proposals.

Per capita recreation use rates from earlier studies of the north coast were applied to the population within each 50-mile zone, and the products for all zones were totaled. This total, representing a potential demand for 1960, was then projected into future decades by applying population growth and recreation use factors to each successive decade. Table 6 summarizes recreation for Tenmile Creek and Panther reservoir sites. The Standley reservoir proposal was incorporated into the study too late for a complete population study so the maximum use for Standley was based upon recreation land capacity. In the case of the reservoir proposals herein described, recreation demand potentials are limited by available recreation lands and water surfaces.

Recreation use estimates for each reservoir proposal are in the tables of recreation use and costs presented later in the text.

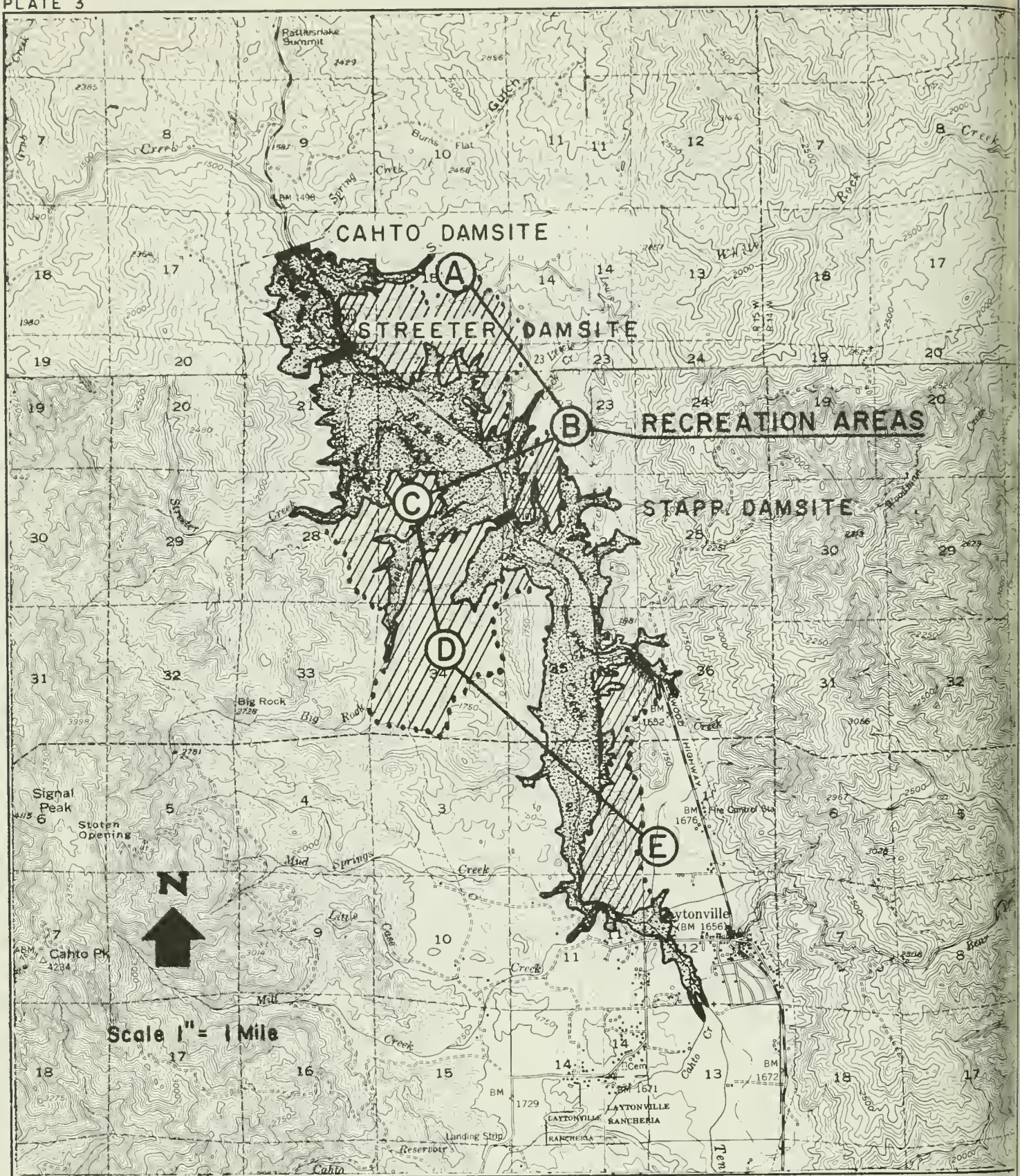
TABLE 6. Summary of Visitor Demand Projections For Water-Associated Recreation

Year	Estimated Visitor Days Demand (Thousands)	
	Tenmile Creek	Panther
1960	262	260
1970	458	455
1980	722	717
1990	1,059	1,053
2000	1,460	1,450
2010	1,936	1,924
2020	2,454	2,438
2030	3,050	3,031
2040	3,699	3,676
2050	4,423	4,396
2060	5,158	5,127
2070	5,920	5,850

RECREATION COSTS

All capital outlay costs have been computed on the basis of unit costs presented in the Department of Parks and Recreation Planning Manual. Capital costs in this report are preliminary, serving as indicators of relative costs between the various project proposals. Detailed costs should be prepared when specific projects are selected for advanced study. Standard Recreation Contract Services Unit costs were employed in computing operation, maintenance, and replacement costs. Costs of recreation lands, access roads, relocation of existing roads, and escalation are not included in these cost estimates.

PLATE 3



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STATE OF CALIFORNIA
DIVISION OF BEACHES AND PARKS
DEPARTMENT OF PARKS AND RECREATION

APPROVED _____ DATE _____
DEPUTY CHIEF, DIVISION OF BEACHES AND PARKS

SOUTH FORK EEL RIVER STUD
TEN MILE CREEK RESERVOIR SIT
POTENTIAL RECREATION AREAS

97873 10-63 800

RESERVOIR PROPOSALS

Tenmile Creek

Tenmile Creek originates in Laytonville Valley. This valley is located approximately 45 miles north of Ukiah on U. S. Highway 101 in Mendocino County. The valley, formed by a structural depression of the coast range, encompasses an area of 11.66 square miles. Elevations on the valley range from 1,450 feet to 1,750 feet. Rainfall over a 15-year period averaged 56.20 inches annually.

Laytonville Valley is drained by two streams. Long Valley Creek drains from the valley to the south and Tenmile Creek drains from the valley to the north. Tenmile Creek arcs to the west as it proceeds downstream to join with the South Fork of the Eel River. The topography changes from gentle slopes in Laytonville Valley to progressively steeper slopes downstream. Three damsite locations were evaluated. Maximum reservoir surface elevation is limited by topography to 1,600 feet at each of three sites. Since each damsite has the potential of being at the same maximum elevation, each successive downstream damsite would incorporate the reservoir pool of the preceding damsite. Maximum storage and surface area would be attained at the Cahto damsite. Plate 3 shows the relative locations of each reservoir proposal on Tenmile Creek.

For economic analysis, three elevations, 1,580, 1,540, and 1,520 feet mean sea level, were considered for each damsite.

Several factors indicate a reservoir on Tenmile Creek could attract and support large numbers of recreation users.

First, large acreages available on relatively gentle slopes are conducive to recreational development.

Second, proximity to U. S. Highway 101 would provide easy access to recreation developments from major population centers.

Third, the relatively warmer climate at this location would probably extend the recreation season beyond the length normally experienced for north coastal areas.

Fourth, it would relieve some of the heavy transient use occurring at redwood state parks.

Recreation Use and Costs

If water releases are made to improve downstream flows in the summer, the greater water surface and storage capacity of the Cahto damsite would provide proportionately more water for reservoir recreation purposes through the summer use season. Preliminary analysis of recreation lands available at each damsite using 20-foot contour intervals are indicated in Table 7.

Tables 8 through 15 present recreation use and cost estimates for each reservoir site on Tenmile Creek. These sites are presently accessible only through locked gates; therefore, existing use was assumed to be neglible and was not deducted from estimated use.

Aerial Photographs 1, 2 and 3 present a picture of the general topography and vegetative cover at proposed reservoir sites.

TABLE 7. Tenmile Creek
Potential Recreation Area Acreages[1/]

Damsite	Designated Area	Acres Elevation 1580'	Acres Elevation 1540'	Acres Elevation 1520'
STAPP	E	443	642	0
	B	130	135	0
	D	690	728	0
Subtotal		1,263	1,505	0
STREETER	C	348	444	444
	A	255	255	345
Subtotal		1,866	2,204	789
CAHTO	A	128	128	156
Total		1,994	2,332	945

1/ Based upon 20-foot contours--1" = 600' mapping; slopes not greater than 20 percent.

Minimum pool is 1,520 feet M.S.L. at Cahto and Streeter damsites.

Aerial Photograph 1

Laytonville Valley and Tenmile Creek looking south (upstream) from approximate locale of STREETER DAMSITE. Highway 101 on left. Damsite at approximate center of picture. See Plate 3.

Aerial Photograph 2

Laytonville Valley and Tenmile Creek looking north (downstream) from about one mile west of Laytonville near terminus of proposed reservoir. Recreation Area "E" at right center. Approximately 640 acres. See Plate 3.

Aerial Photograph 3

Laytonville Valley and Tenmile Creek looking north (downstream) toward STREETER DAMSITE. Alignment of present Highway 101. Recreation Area "C" at left center. Approximately 440 acres. See Plate 3.

TABLE 8. Estimated Recreation Use and Costs[1/] Stapp Reservoir At Elevation 1,580' M.S.L. (In Thousands)

Decade	Net Visitor Use 2/	Capital Costs 3/	Operation and Maintenance 4/	Replacement 5/	Total
1970-79	4,830	$ 3,010	$ 1,449	$ 1,050	$ 5,509
1980-89	6,960	1,455	2,088	1,560	5,103
1990-99	9,300	1,755	2,790	2,180	6,725
2000-09	12,680	2,182	3,804	2,940	8,926
2010-19	16,310	2,482	4,893	3,810	11,185
2020-29	19,940	2,782	5,982	4,780	13,544
2030-39	22,690	495	6,807	4,960	12,262
2040-49	26,050	510	7,815	5,130	13,455
2050-59	29,330	510	8,799	5,310	14,619
2060-69	32,550	510	9,765	5,490	15,765

TABLE 9. Estimated Recreation Use and Costs[1/] Stapp Reservoir At Elevation 1,540' M.S.L. (In Thousands)

Decade	Net Visitor Use 2/	Capital Costs 3/	Operation and Maintenance 4/	Replacement 5/	Total
1970-79	4,510	$ 2,960	$ 1,353	$ 1,040	$ 4,353
1980-89	6,640	1,455	1,992	1,550	4,997
1990-99	8,980	1,755	2,694	2,160	6,609
2000-09	12,360	2,182	3,708	2,920	8,810
2010-19	15,990	2,482	4,797	3,790	11,069
2020-29	19,630	2,482	5,889	4,660	13,031
2030-39	23,680	2,895	7,104	5,670	15,669
2040-49	27,040	510	8,112	5,850	14,472
2050-59	30,320	510	9,096	6,030	15,636
2060-69	33,530	510	10,059	6,208	16,777

TABLE 10. Estimated Recreation Use and Costs[1/] Streeter Reservoir At Elevation 1,580' M.S.L. (In Thousands)

Decade	Net Visitor Use 2/	Capital Costs 3/	Operation and Maintenance 4/	Replacement 5/	Total
1970-79	3,850	$ 3,060	$ 1,155	$ 1,070	$ 5,295
1980-89	7,650	1,505	2,295	1,590	5,390
1990-99	9,980	1,755	2,994	2,210	6,959
2000-09	13,370	2,182	4,011	2,980	9,173
2010-19	17,000	2,482	5,100	3,840	11,422
2020-29	20,630	2,482	6,189	4,710	13,381
2030-39	24,920	3,195	7,476	5,830	16,501
2040-49	29,730	2,910	8,919	6,850	18,679
2050-59	33,010	510	9,903	7,030	17,443
2060-69	36,220	510	10,866	7,210	18,586

TABLE 11. Estimated Recreation Use and Costs[1/] Streeter Reservoir At Elevation 1,540' M.S.L. (In Thousands)

Decade	Net Visitor Use 2/	Capital Costs 3/	Operation and Maintenance 4/	Replacement 5/	Total
1970-79	5,150	$ 3,035	$ 1,545	$ 1,060	$ 5,640
1980-89	7,280	1,455	2,184	1,570	5,209
1990-99	9,620	1,755	2,886	2,190	6,831
2000-09	13,000	2,182	3,900	2,950	9,032
2010-19	16,550	2,482	4,965	3,820	11,267
2020-29	20,260	2,482	6,078	4,690	13,250
2030-39	24,550	3,195	7,365	5,800	16,360
2040-49	28,234	1,110	8,470	6,190	15,770
2050-59	31,518	510	9,455	6,370	16,335
2060-69	34,777	510	10,433	6,550	17,493

1/ Coyote Dam and Reservoir used as comparable reservoir. Based on maximum land acquisition and optimum development of all lands suitable for recreation.

2/ Existing use is negligible and was not considered for Tenmile Creek reservoir proposals.

3/ Capital costs were based upon standard unit costs.

4/ Computed at 30 cents per visitor day.

5/ Computed at 3.5 percent of cumulative annual capital costs.

TABLE 12. Estimated Recreation Use and Costs[1/]. Streeter Reservoir At Elevation 1,520' M.S.L. (In Thousands)

Decade	Net Visitor Use [2/]	Capital Costs [3/]	Operation and Maintenance [4/]	Replacement [5/]	Total
1970-79	4,740	$ 2,985	$ 1,422	$ 1,040	$ 5,447
1980-89	6,870	1,455	2,061	1,550	5,066
1990-99	9,200	1,755	2,760	2,170	6,685
2000-09	12,580	2,182	3,774	2,930	8,886
2010-19	14,910	382	4,473	3,060	7,915
2020-29	17,180	382	5,154	3,200	8,736
2030-39	19,880	495	5,964	3,370	9,829
2040-49	23,250	510	6,975	3,550	11,035
2050-59	26,530	510	7,959	3,730	12,199
2060-69	29,780	510	8,934	3,900	13,344

TABLE 13. Estimated Recreation Use and Costs[1/] Cahto Reservoir At Elevation 1,580' M.S.L. (In Thousands)

Decade	Net Visitor Use [2/]	Capital Costs [3/]	Operation and Maintenance [4/]	Replacement [5/]	Total
1970-79	5,380	$ 3,060	$ 1,614	$ 1,071	$ 5,745
1980-89	7,890	1,530	2,367	1,606	5,503
1990-99	10,220	1,755	3,066	2,221	7,042
2000-09	13,600	2,182	4,080	2,984	9,246
2010-19	17,240	2,482	5,172	3,853	11,507
2020-29	20,870	2,482	6,261	4,722	13,465
2030-39	25,160	3,195	7,548	5,840	16,583
2040-49	30,430	3,510	9,129	7,069	19,708
2050-59	34,370	1,710	10,311	7,667	19,688
2060-69	37,575	585	11,272	7,872	19,729

TABLE 14. Estimated Recreation Use and Costs[1/] Cahto Reservoir At Elevation 1,540' M.S.L. (In Thousands)

Decade	Net Visitor Use [2/]	Capital Costs [3/]	Operation and Maintenance [4/]	Replacement [5/]	Total
1970-79	5,150	$ 3,060	$ 1,545	$ 1,071	$ 5,676
1980-89	7,280	1,455	2,184	1,580	5,219
1990-99	9,620	1,755	2,886	2,194	6,835
2000-09	13,000	2,182	3,900	2,958	9,040
2010-19	16,630	2,482	4,989	3,827	11,298
2020-29	20,270	2,482	6,081	4,696	13,259
2030-39	24,550	3,195	7,365	5,814	16,374
2040-49	29,830	3,510	8,949	7,042	19,501
2050-59	35,070	3,210	10,521	8,166	21,897
2060-69	38,285	510	11,485	8,344	20,339

TABLE 15. Estimated Recreation Use and Costs[1/] Cahto Reservoir At Elevation 1,520' M.S.L. (In Thousands)

Decade	Net Visitor Use [2/]	Capital Costs [3/]	Operation and Maintenance [4/]	Replacement [5/]	Total
1970-79	4,870	$ 3,010	$ 1,461	$ 1,050	$ 5,521
1980-89	7,000	1,455	2,100	1,560	5,115
1990-99	9,330	1,755	2,799	2,180	6,734
2000-09	12,720	2,182	3,816	2,940	8,938
2010-19	15,670	1,882	4,701	3,200	9,783
2020-29	18,150	382	5,445	3,330	9,157
2030-39	20,650	495	6,195	3,500	10,190
2040-49	24,220	510	7,266	3,680	11,456
2050-59	27,500	510	8,250	3,860	12,620
2060-69	30,710	510	9,213	4,040	13,763

1/ Coyote Dam and Reservoir used as comparable reservoir. Based on maximum land acquisition and optimum development of all lands suitable for recreation.

2/ Existing use is negligible and was not considered for Tenmile Creek reservoir proposals.

3/ Capital costs were based upon standard unit costs.

4/ Computed at 30 cents per visitor day.

5/ Computed at 3.5 percent of cumulative annual capital costs.

The variance in visitor use and facility cost estimates among reservoir sites is due to differences in land and water surface acreages and the appropriate support facilities which could be provided at each of the selected elevations.

These analyses indicate that a reservoir at the Cahto site would provide the greatest amount of recreation use. Large scale mapping recently obtained from the Department of Water Resources indicates a desirable elevation for recreational purposes at about 1,580 feet mean sea level.

Panther Reservoir

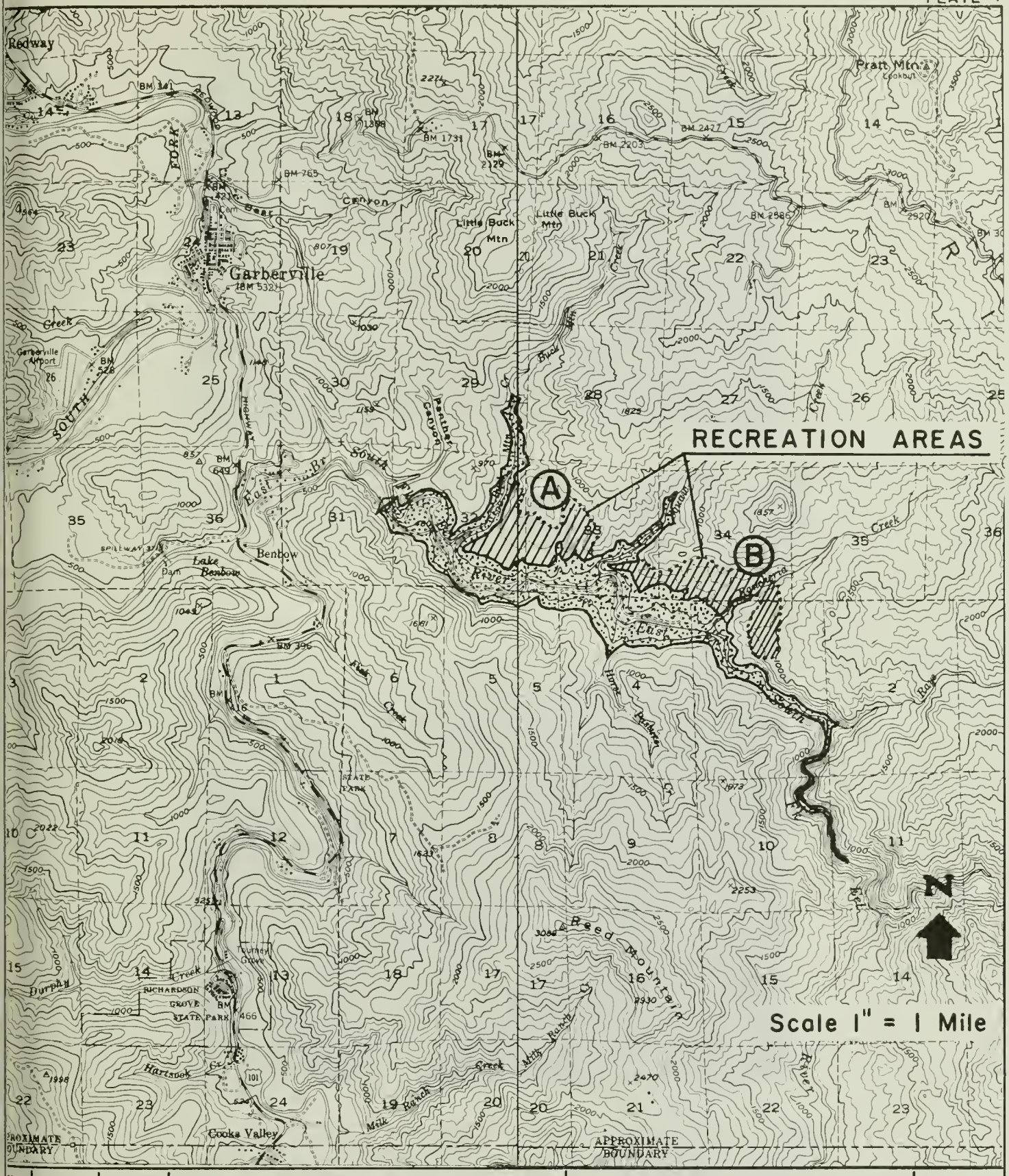
Panther Reservoir site is located in Humboldt County on the East Branch of the South Fork Eel River one mile east of the Benbow Lake State Recreation Area.

Vegetation is predominately Douglas fir intermingled with California laurel and madrone. Logging activities are prevalent on the north-facing slopes. Erosion and slide activity has occurred on these slopes. Grasslands fringed with oak and madrone dominate on slopes with southern exposure.

Reservoir lands are steep, and become more precipitous proceeding upstream. The area has an apparent proclivity for slides. Elaborate development should not be constructed on north facing slopes. These slopes, however, are well suited to riding and hiking trail development. Analysis based on 20-foot contour intervals located approximately 340 acres of developable land scattered widely throughout the project area. The amount of land varies considerably with the reservoir elevation selected.

Two areas on south facing slopes have topographic features and sufficient lands for recreation development as indicated on Plate 4. Aerial Photograph 4 shows Area A which is located at elevation 600 feet and comprises approximately 90 acres. This area is particularly suited to campground development. Tree fringes consisting of large oak and madrone mingled with Douglas fir surround large, open grassland areas. These grass areas should be left undisturbed to conserve open space concepts.

The second potential recreation area, Area B comprising approximately 82 acres, is located at an elevation of 500 feet. This area would



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APPROVED _____ DATE _____
DEPUTY CHIEF, DIVISION OF BEACHES AND PARKS

SOUTH FORK EEL RIVER PANTHER RESERVOIR POTENTIAL RECEREATION AREAS

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Aerial Photograph 4. PANTHER RESERVOIR SITE looking west. Potential recreation lands on bluff to right. Approximate elevation 600 feet. Shown on Plate 4 as Recreation Area "A". Approximately 90 acres.

Aerial Photograph 5. PANTHER RESERVOIR SITE looking west. Potential recreation lands on right at elevation 500 feet. Shown on Plate 4 as Recreation Area "B". Approximately 82 acres.

be a very desirable day use area and slopes could be readily adapted for beach development. This site is shown on Aerial Photograph 5.

A reservoir water surface elevation of 500 feet would allow full utilization of both recreation areas. The upper area could be utilized for camping and the lower area for day use. Table 16 gives estimated costs and visitor use at a reservoir surface elevation of 500 feet.

A reservoir with a water surface elevation of 600 feet would provide a significantly larger water surface and storage capacity. The lower recreation area, however, would be flooded out. Part of the upper area would have to be utilized for day use rather than camping. This would result in a loss of total visitor use and a less satisfactory utilization of the natural attributes of the recreation lands. This reduction in use is reflected in Table 17.

Considerable discussion centered around the possibility of removing Benbow Dam. Table 18 summarizes net use estimates for Panther Reservoir at elevation 500 feet with Benbow Dam eliminated. Projected use estimates would exceed land capacities in the first decade. Existing use has been projected until the capacity of existing and proposed development at Benbow Lake State Recreation Area is reached. It appears that negative benefits would accrue to the project if Benbow Dam was removed.

It should be emphasized that road access costs have not been included in capital costs as presented in Table 16, 17, and 18. These costs should be more clearly defined before a determination of economic justification or financial feasibility is made. Because of the adverse topographic features at this site, and the possibility of slides, providing access may be a significant cost item.

It is possible that greater recreation benefits at less cost would accrue if the Department of Water Resources, the Division of Beaches and Parks, and the Department of Fish and Game redesigned the existing Benbow Dam. Because of planned freeway alignments, the Division of Beaches and Parks will acquire additional property for the Benbow Lake State Recreation Area. Considerable changes in development planning will be inaugurated. These changes could provide time for a cooperative endeavor

TABLE 16. Estimated Recreation Use and Costs[1]
Panther Reservoir At Elevation 500' M.S.L.
(In Thousands)

Decade	Net Visitor Use [2]	Capital Costs [3]	Operation and Maintenance [4]	Replacement [5]	Total
1970-79	1,110	$1,142	$333	$400	$1,875
1980-89	1,110	-	333	400	733
1990-99	1,110	-	333	400	733
2000-09	1,110	-	333	400	733
2010-19	1,110	-	333	400	733
2020-29	1,110	-	333	400	733
2030-39	1,110	-	333	400	733
2040-49	1,110	-	333	400	733
2050-59	1,110	-	333	400	733
2060-69	1,110	-	333	400	733

TABLE 17. Estimated Recreation Use and Costs[1]
Panther Reservoir At Elevation 600' M.S.L.
(In Thousands)

Decade	Net Visitor Use [2]	Capital Costs [3]	Operation and Maintenance [4]	Replacement [5]	Total
1970-79	560	$730	$168	$255	$1,153
1980-89	560	-	168	255	423
1990-99	560	-	168	255	423
2000-09	560	-	168	255	423
2010-19	560	-	168	255	423
2020-29	560	-	168	255	423
2030-39	560	-	168	255	423
2040-49	560	-	168	255	423
2050-59	560	-	168	255	423
2060-69	560	-	168	255	423

1/ Coyote Dam and Reservoir used as comparable reservoir. Based on maximum land acquisition and optimum development of all lands suitable for recreation.
2/ Existing use is negligible and was not considered for this reservoir proposal.
3/ Capital costs were based upon standard unit costs.
4/ Computed at 30 cents per visitor day.
5/ Computed at 3.5 percent of cumulative annual capital costs.

to design and build a dam more amiable to park administrators and the Department of Fish and Game.

TABLE 18. Summary of Estimated Net Visitor Use
Panther Reservoir At Elevation 500'
With Benbow Dam Removed
(In Thousands)

Decade	Gross Estimated Use	Existing Use 1/	Net Use
1970-79	1,110	454	656
1980-89	1,110	706	410
1990-99	1,110	1,029	81
2000-09	1,110	1,216	-106
2010-19	1,110	1,216	-106
2020-29	1,110	1,216	-106
2030-39	1,110	1,216	-106
2040-49	1,110	1,216	-106
2050-59	1,110	1,216	-106
2060-69	1,110	1,216	-106

1/ Existing Benbow State Recreation Area.

Standley Reservoir

The proposed Standley damsite and reservoir is located in Mendocino County on the South Fork Eel River approximately 7 miles southwest of the town of Laytonville.

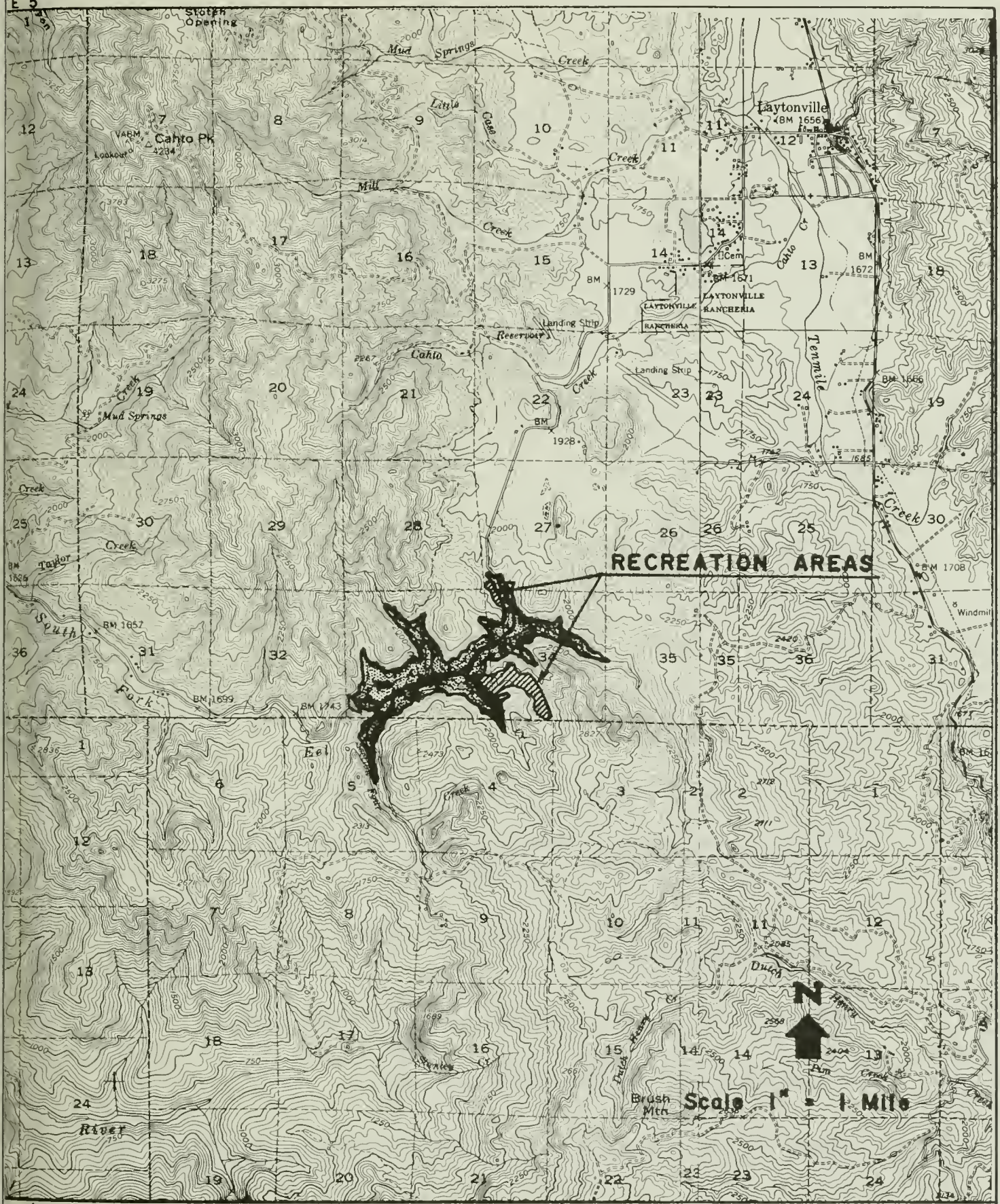
The reservoir site is relatively remote from main travel routes. At present the area is reached from Highway 101 by traveling west from Laytonville on an improved dirt road. Parts of this road would be inundated if a dam were built. Because of the steep topography of this area, road relocation costs may be high.

An approximate water surface area of 320 acres would be available for recreation purposes. Since the stream at this point is intermittent, a reservoir might permit all year flows in the stream for fishery enhancement. The small storage capacity of the proposed reservoir would have very little value for flood control and indicates a degree of fluctuation which could be detrimental to recreational use.

Recreation lands at this reservoir site are small and widely scattered. Topographic maps show 4 land areas ranging from 2 to 40 acres. Most of these recreation lands are located some distance from proposed water surface elevations. Slopes permitting access to the proposed reservoir are excessively steep, ranging up to 66 percent. Lower water surface elevations would not add to the amount of recreation land, but would make these desirable lands more remote from the water surface. Two recreation land areas were selected for potential development as indicated on Plate 5.

Table 19 summarizes development costs and visitor use estimates at this reservoir site with optimum development.

Standley Reservoir has little recreation potential. Considering the relatively small local population and the poor quality of developable lands, the utility of this reservoir for recreational purposes is doubtful. This reservoir site should not be considered for recreational purposes.



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DEPUTY CHIEF, DIVISION OF BEACHES AND PARKS

SOUTH FORK EEL RIVER STUDY
STANDLEY RESERVOIR
POTENTIAL RECREATION AREAS

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TABLE 19. Estimated Recreation Use and Costs[1/]
Standley Reservoir at Elevation 1,900' M.S.L.
(In Thousands)

Decade	Net Visitor Use 2/	Capital Costs 3/	Operation and Maintenance 4/	Replacement 5/	Total
1970-79	600	$700	$180	$245	$1,125
1980-89	600	-	180	245	425
1990-99	600	-	180	245	425
2000-09	600	-	180	245	425
2010-19	600	-	180	245	425
2020-29	600	-	180	245	425
2030-39	600	-	180	245	425
2040-49	600	-	180	245	425
2050-59	600	-	180	245	425
2060-69	600	-	180	245	425

1/ Based on maximum land acquisition and optimum development of all lands suitable for recreation.

2/ Existing stream use is negligible and was not considered for this reservoir.

3/ Capital costs were based upon standard unit costs.

4/ Computed at 30 cents per visitor day.

5/ Computed at 3.5 percent of cumulative annual capital costs.

PROJECT PROPERTY OWNERSHIP

An examination of property ownership based upon U. S. Bureau of Land Management mapping indicates that all property which would be required for project development is privately owned.

Northwestern Pacific and Central Pacific (Southern Pacific) Railroad Companies own lands at the proposed Panther Reservoir site as summarized in Table 20.

TABLE 20. Property Ownership Brief
Potential Reservoir Sites

Reservoir Damsite	Township	Range	Section	Ownership[1]
		Mt. Diablo Base and Meridian		
Stapp	21N	15W	12,11,2	Patented
	22N	15W	36,35,26,27	Patented
Streeter	22N	15W	34,28,22,21,23	Patented
Cahto	22N	15W	16	Patented[2]
Standley	21N	15W	27,33,34	Patented
	20N	15W	4,5	Patented
		Humboldt Base and Meridian		
Panther	4S	4E	31,33	N.W. Pac.R.R.
	4S	4E	32,34	Patented
	5S	4E	5,3	C. Pac. R.R.
	5S	4E	2,4	Patented

1/ Original patents issued to private parties.

2/ Originally state school lands. Patent issued 1882 to private interests. (Per State Land Division, 2-10-66)

LOW LEVEL RESERVOIR POTENTIALS

This recreation reconnaissance study was devoted to relatively large reservoir proposals on tributaries to the South Fork Eel River. During the study considerable local interest was generated for water resources development, particularly in the communities of Myers Flat, Miranda, and Garberville. Comments received from individuals and leaders in these communities and expressed during public hearings held after the winter flood of 1964-65, pointed increasingly to the need for study of low-level reservoir potentials. The concept of low-level recreation pools is particularly important because of the following problems encountered during the reconnaissance study.

There are unstable geological formations in the South Fork Eel River Basin. This problem has contributed to the difficulty of locating large developable damsites. When potential damsites were found, they often were located where reservoir waters could activate old slides creating a hazard of hillsides sliding into newly constructed reservoirs.

The area is subject to high annual stream flows, often approaching flood velocities. The deposition of large masses of sedimentary materials into reservoirs by periodic floods could reduce the effective life expectancy of large reservoir proposals.

High level dams also affect fishery resources. These dams impede or block migration of anadromous species. Also, the impoundment of the waters of natural streams has an adverse effect upon the environment through which anadromous species of fish must pass.

For the above reasons, more emphasis should be placed upon the study of low-level reservoir pools on the South Fork Eel River. These pools could be formed by the construction of semi-permanent dam structures. These structures could be built by various construction methods and materials.

Semi-permanent structures have an advantage over permanent structures for recreation pools. They can be removed at the end of the recreation season thus permitting the river to cleanse itself of sediments. The removal of these impoundment structures before annual fish migrations

begin should permit fish to reach spawning areas with minimum difficulty. Such pools might enhance the environment of juvenile fish by providing lower summer water temperatures. Proper design should permit fish to move downstream at will. For recreational purposes, such reservoir pools could be constructed at comparatively low cost.

There are at least three areas where semi-permanent reservoir pools already exist: Benbow Lake State Recreation Area, Memorial Park in Healdsburg, and a series of low-level reservoirs in the Guerneville area.

In anticipation of future recreation planning needs the Recreation Contract Services Unit initiated recreation surveys at Benbow Lake State Recreation Area and Healdsburg Memorial Park during the summer of 1966. Some of the data collected at Benbow Lake State Recreation Area is presented in this report.

Low-level, semi-permanent dam structures should occupy an important position in future resource planning in the South Fork Eel River Basin.

FUTURE STUDIES

Future studies in the South Fork Eel River hydrographic subunits should consider the feasibility of the Cahto Reservoir site on Tenmile Creek. Of all the major projects considered in this study the Cahto damsite has the highest potential for comprehensive public recreational development and also offers opportunities for large scale concession operations.

Of greater urgency to the communities of the South Fork Eel River Basin and the development of local water resources and associated recreation is the need for controlling the high winter runoff. Projects necessary to provide flood control are of such magnitude that economic justification for their construction is difficult to obtain.

The U. S. Corps of Engineers has suggested that a less expensive alternate to protect lives and property is to move communities from areas subject to flood damages. If such an alternate is adopted, there is a possibility that abandoned areas could be utilized for seasonal recreation purposes. Myers Flat lends itself readily to this concept. Low-level, semi-permanent reservoirs could be placed in the river adjacent to these abandoned areas and the existing local business communities could provide necessary visitor services and maintenance personnel. These developments would be an asset to recreation and to the local economies.

Low-level, semi-permanent dam structures may be of significance to many of the local communities in the South Fork Eel River Basin. A reconnaissance study should be conducted to define the opportunities in this area for development of low-level recreation pools.

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Appendix C

FISH AND WILDLIFE

By

Department of Fish and Game

State of California The Resources Agen

Memorandum

To : Honorable William R. Gianelli, Director
Department of Water Resources
1416 Ninth Street
Sacramento, California 95814

Date: June 30, 1967

From : **Department of Fish and Game**

Subject: WP- State of California, Department of Water Resources, North Coastal Area Investigation, South Fork Eel River Study, Bulletin No. 173.

I am pleased to transmit herewith a reconnaissance report entitled "Preliminary Fish and Wildlife Evaluation of Possible Water Projects in the South Fork Eel River Basin" which is scheduled to be published as Appendix C to Bulletin No. 173, "South Fork Eel River Study". This report completes the preliminary fish and wildlife studies related to this investigation. These studies were carried out and the report prepared by the Fish and Game Contract Services Section under provisions of various interagency agreements with your Department.

The report provides preliminary information regarding the fish and wildlife resources affected by water projects proposed for the South Fork Eel River Basin, describes measures required to maintain these resources, and defines possible enhancement opportunities related to the proposed developments. Due to the reconnaissance nature of this investigation, substantial additional work will be required to provide final recommendations for the preservation and enhancement of fish and wildlife.

This evaluation was based on reservoirs operated primarily for fish, wildlife, and recreation enhancement in order to determine optimum benefits for these purposes. Modification of the projects to include other purposes may be incompatible with fishery preservation and enhancement due to the relatively limited volumes of cool water necessary for fishery maintenance.

Even if operated solely for recreation, fish, and wildlife, it is possible there may be water temperature problems at times. This possibility will require thorough evaluation in future studies.

Director

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State of California
The Resources Agency
DEPARTMENT OF FISH AND GAME
Water Projects Branch

RONALD REAGAN, Governor, State of California
NORMAN B. LIVERMORE, JR., Administrator, The Resources Agency
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SUMMARY

A reconnaissance-level investigation was conducted to determine the effects on fish and wildlife of several dams proposed for the South Fork Eel River Basin. These projects are being studied by the Department of Water Resources for the possible purposes of recreation, local water supply, flood control, and fishery enhancement.

Significant fish and wildlife populations would be affected by all of the proposed projects and artificial propagation facilities, stream-flow requirements, and wildlife mitigation measures are recommended to maintain these resources.

In addition to the creation of new reservoir fisheries, certain of the proposed projects may have potential for enhancement of downstream fisheries if water temperatures are suitable. This could be accomplished by improvement of silver salmon and steelhead nursery areas below the dams and provision of increased spawning flows for king salmon in the lower South Fork Eel River. The river sport fishery could also be extended over a longer period by higher fall flows which would increase potential angling use.

The studies indicated that the Cahto, Sebow and Frost Reservoir sites were most desirable from a fisheries standpoint. Generally, these projects would have the least detrimental effect on fish and wildlife and the most enhancement potential.

Additional study is recommended to predict post-project water temperatures, existing resources, and more accurately define maintenance and enhancement requirements, with accompanying costs and benefits.

Conclusions

1. All of the proposed projects would block and inundate important spawning and nursery areas for anadromous fish, and would inundate valuable wildlife habitat. Thus, any of the projects would affect sizeable populations of fish and wildlife.

2. Depending on the results of recommended temperature studies, Sebow or Cahto Reservoir would be the most desirable project among the

several alternatives proposed for the Tenmile Creek drainage. Frost Reservoir may also have significant fishery potential.

3. It is questionable if fishery losses could be mitigated successfully with Stapp Reservoir constructed at any proposed elevation due to its limited volume of cool water. Similarly, a small dam at the Panther site (elevation 500 feet) would create serious fishery problems due to limited hypolimnion water. There would be no downstream enhancement potential with either of these projects. Geology at the Standley site appears to be poor, limiting the dam to elevations less than 1880 feet. This small size would severely limit downstream enhancement potential.

4. A significant amount of fishery enhancement would result from the reservoir fishery and from downstream releases to improve nursery areas for juvenile silver salmon and steelhead, if any of the other projects is constructed. The enhancement potential of Streeter or Cahto Reservoirs at elevations under 1580 feet may be limited during dry years due to their relatively small volumes of cool water. However, Cahto (elevation 1580 feet or higher) or Sebow Reservoirs on Tenmile Creek, and a large Panther Reservoir (surface elevation 600 feet) on the East Branch, would have potential for enhancing king salmon spawning areas in the lower South Fork Eel River.

5. If water temperatures are suitable, downstream releases in excess of 100 cfs after October 1 each year would allow anadromous fish to migrate into the South Fork Eel River and distribute themselves throughout the drainage prior to the first major rains and thereby substantially lengthen the river sport fishery.

6. Large releases for flood control or local water supply may be incompatible with significant downstream fisheries enhancement, and might preclude successful fish maintenance, because such releases would rapidly deplete the limited hypolimnion water in the proposed reservoirs.

Recommendations

1. Due to the proposed extensive development of the remainder of the Eel River Basin, any water project development in the South Fork drainage should be directed at increasing production of salmon and steelhead, and improving the river sport fishery in preference to other possible project purposes. These resources make an important contribution to the economy of the area, which is rapidly becoming recreation-based.

2. A watershed management program, including flood plain zoning, should be developed for the South Fork Eel River drainage to preserve the natural beauty of the area, while reducing flood damage to private property, and avoiding the need for large and expensive flood control projects. Such a program would assist measurably in developing the fish, wildlife, and recreation potential of the basin.

3. Prior to authorization of any proposed project, additional study should be completed to more accurately inventory the fish and wildlife resources, and to more precisely define the measures required for preservation or enhancement of these resources. Specific areas of further study should include:

a. An inventory of the anadromous fish spawning in the project areas in order to size and design required artificial propagation facilities. This could probably best be accomplished by tagging and spawning ground surveys. Similarly, more detailed surveys of wildlife populations and habitat would be required to more accurately define mitigation methods and costs.

b. A competent study by a recognized authority should be made to more accurately predict water temperatures in the proposed reservoirs and to determine the rate of downstream warming. Because water temperatures could be a major problem in the operation of artificial propagation facilities and in providing downstream enhancement, these temperature studies should be completed prior to initiation of the feasibility level investigation of the projects so the results would be available during the fishery evaluation.

c. More accurate estimates should be obtained of the numbers of downstream migrants and juvenile salmonids residing in the streams under study. Enumeration of standing crops of juvenile salmonids in good nursery areas should also be undertaken to more accurately define potential benefits resulting from improved nursery flows.

d. Increased emphasis should be given to the problem of defining potential benefits associated with increasing spawning area for king salmon in the lower South Fork Eel River. This could be accomplished by surveys to determine the number, size, and quality of spawning riffles, and additional measurements of the relationship between streamflow and usable spawning area.

e. A survey should be made to determine land ownership and potential access problems in areas which could receive increased angler use attributed to the proposed projects. It may be necessary to purchase land or easements and to provide facilities to support the predicted use.

FIGURE 1

NORTH COASTAL AREA INVESTIGATION
SOUTH FORK EEL RIVER STUDY
POSSIBLE WATER DEVELOPMENTS
IN
THE EEL RIVER BASIN
SCALE OF MILES
4 0 4 8 12 16
Arcata
Eureka
Fortuna
Weott
Miranda
Alderpoint
Garberville
Benbow
Leggett
Laytonville
Dos Rios
Willits
Fort Bragg
EATON RES.
BASELINE RES.
SEQUOIA RES.
PANTHER RES.
MINA RES.
BELL SPRINGS RES.
DOS RIOS RES.
CAHTO RES.
ENGLISH RIDGE RES.
PRESSLEY RES.
RUTH RES
LAKE PILLSBURY
DOS RIOS - GRINDSTONE TUNNEL
GARRETT TUNNEL
EEL RIVER BASIN BOUNDARY
PACIFIC OCEAN
HUMBOLDT CO
MENDOCINO CO
TRINITY CO
TEHAMA CO
GLENN CO
LAKE CO
Eel River
South Fork Eel River
North Fork Eel River
Van Duzen River
Mad River
Redwood Creek
Elk River
Bear River
Yager Creek
Bull Creek
Salmon Creek
Rattlesnake Creek
Ten Mile River
Outlet Creek
Tomki Creek
Black Butte River
Elk Creek
Stony Creek

INTRODUCTION

The California Water Plan, described in Bulletin No. 3 of the Department of Water Resources, proposed the construction of small storage reservoirs in many north coast drainages where major export projects were not planned. Such projects could meet local requirements for irrigation, urban, and industrial water supplies, and might also provide fish, wildlife, and recreation enhancement along with incidental flood control.

In compensation for the loss of stream fishing area through the construction of major reservoirs in the Eel River basin, the Plan envisioned that the South Fork Eel River could be developed solely for enhancement of the anadromous fishery and general recreational potential. Figure 1 indicates the relationship of the South Fork and its proposed reservoirs to the major export projects planned for the Eel River basin.

The recreation service industry ranks second to the forest products industry in the economy of the South Fork basin at the present time, and will become the major business in the near future.

Since the fish and wildlife resources of the area support a large portion of the recreational use, proposed water project development should be directed at maximizing the fish and wildlife enhancement potential of the basin.

Scope and Objectives

This report was prepared to provide preliminary information regarding the fish and wildlife resources affected by water projects proposed for the South Fork Eel River basin. It is based on limited reconnaissance studies conducted as part of the preliminary planning phases of the South Fork Eel River Investigation. The Department of Water Resources is evaluating several possible projects during this investigation, considering the purposes of recreation, local water supply, flood control, and fishery enhancement. Based on this preliminary evaluation, favorable projects will be recommended for more detailed study and determination of economic feasibility. The fish and wildlife studies were conducted by the Contract Services Section of the Department of Fish and Game under various interagency agreements with the Department of Water

Resources. Due to the reconnaissance nature of this investigation, further studies will be required to provide final recommendations for the preservation and enhancement of fish and wildlife.

FISH AND WILDLIFE RESOURCES

Fish

The South Fork Eel River drainage supports sizable runs of king salmon, silver salmon, and steelhead trout. Both species of salmon contribute significantly to sport and commercial ocean fisheries, while the large river sport fishery is based mainly on steelhead.

All of the streams being studied for possible water projects are important spawning and nursery areas for king salmon, silver salmon, and steelhead. Life history details of these species were described in Appendix C to Bulletin No. 92, "Branscomb Project Report", and Appendix C to Bulletin No. 136, "North Coastal Area Investigation", and need not be repeated here.

The numbers of anadromous fish spawning in the South Fork Eel River drainage above Benbow Dam since 1938 are indicated by counts of fish utilizing the fish ladder. These counts do not, of course, reflect the production of fish below the dam, nor do they indicate the number of fish utilizing the various tributaries where dams are proposed.

The salmon and steelhead runs above Benbow Dam have declined significantly since 1952. Numbers of king and silver salmon have dropped to about one-third the level of abundance prior to 1952. The counts of steelhead are slightly more than two-thirds the pre-1952 level. This serious decline is generally attributed to poor watershed management practices, especially careless logging, extensive road building, and overgrazing by livestock.

Wildlife

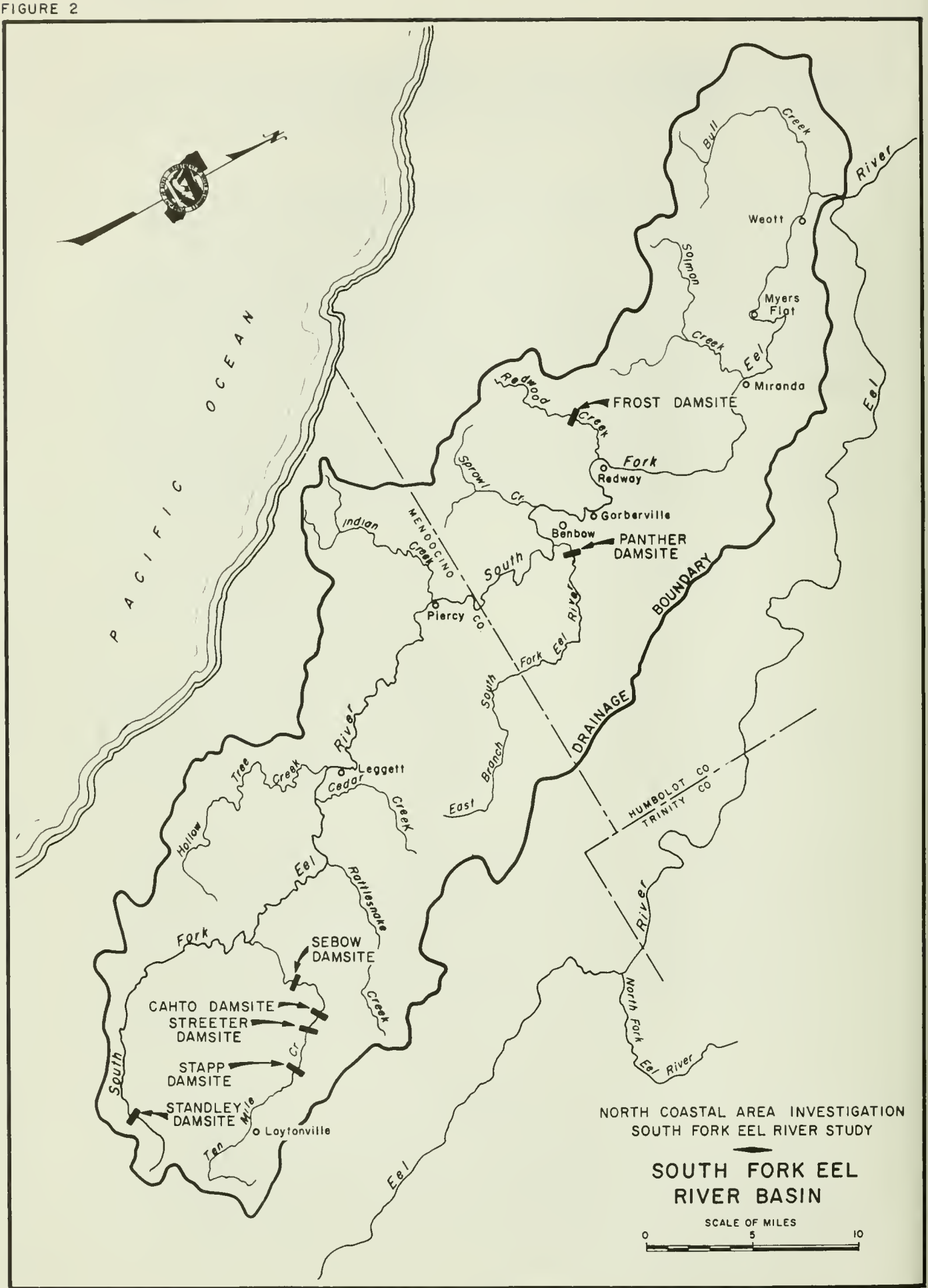
The wildlife habitat of the South Fork Eel River drainage is generally characterized by stands of coniferous timber interspersed with grass, woodland-grass, various types of woodland, several forms of chaparral, and occasional agricultural lands. This variety of habitat types

provides for considerable variation in both resident and migratory wildlife species. Yocom and Dasmann (1957) present a good resume of the plant and wildlife species found in the area.

Most of the coniferous timber in the drainage has been logged, resulting in the various stages of regrowth leading to climax timber conditions. Logging usually increases the wildlife carrying capacity of these lands for a time, but the capacity gradually decreases as the habitat approaches climax conditions. The areas surveyed during this investigation were in various stages of succession, and the wildlife population estimates are therefore subject to change.

Livestock use has affected the areas surveyed, and undoubtedly has had some effect on wildlife numbers. Some areas showed evidence of overuse by livestock which has probably contributed to range decline.

FIGURE 2


PACIFIC OCEAN
Bull Creek
Weott
Salmon Creek
Myers Flat
Eel River
Miranda
Redwood Creek
FROST DAMSITE
Fork
Redway
Sprowl Cr
Gorberville
Benbow
PANTHER DAMSITE
Indian Creek
MENDOCINO CO
South Fork Eel River
Piercy
BOUNDARY
DRAINAGE
South Fork Eel River
Leggett
Tree Creek
Cedar Creek
East Branch
HUMBOLOT CO
TRINITY CO
Hollow
Eel River
Rattlesnake Creek
Fork
SEBOW DAMSITE
CAHTO DAMSITE
STREETER DAMSITE
STAPP DAMSITE
STANDLEY DAMSITE
South Fork
Ten Mile Cr
Laytonville
North Fork Eel River
Eel River
NORTH COASTAL AREA INVESTIGATION
SOUTH FORK EEL RIVER STUDY
SOUTH FORK EEL RIVER BASIN
SCALE OF MILES
0
5
10

PROJECT DESCRIPTIONS

The several alternative projects studied during this investigation are located in Mendocino and Humboldt counties near Laytonville and Garberville. All lie either on the South Fork Eel River or one of its tributaries. Table 1 describes the general features and location of the various possible damsites. Figure 2 graphically indicates the location of each damsite in relation to the South Fork Eel River.

TABLE 1

DESCRIPTION OF POSSIBLE SOUTH FORK EEL RIVER BASIN PROJECTS

Reservoir	Stream	Section	Surface Elevation (feet,MSL)	Dam Height (feet)	Surface Area (acres)	Gross Storage (AF)
Stapp 1/	Tenmile Creek	Sec. 26, T 22 N, R 15 W, MDM	1580	100	705	28,000
Streeter 1/	Tenmile Creek	Sec. 21, T 22 N, R 15 W, MDM	1580	140	1515	80,000
Cahto 1/	Tenmile Creek	Sec. 16, T 22 N, R 15 W, MDM	1580	163	1760	95,500
Sebow 1/	Tenmile Creek	Sec. 18, T 22 N, R 15 W, MDM	1580	200	2590	169,000
Standley	South Fork Eel	Sec. 33, T 21 N, R 15 W, MDM	1880	163	320	16,500
Panther	East Branch	Sec. 31, T 45, R 4 E, HM	600	240	920	80,200
Frost	Redwood Creek	Sec. 17, T 45, R 13 E, HB	700	195	870	55,000

1/ A series of four alternative damsites.

POTENTIAL FISHERY LOSSES AND SUGGESTED MITIGATION

Any of the proposed projects would block and inundate valuable salmon and steelhead spawning and nursery grounds lying upstream from the dams. The distribution of anadromous fish habitat in relation to the proposed projects is illustrated in Table 2. Estimates of the anadromous fish populations historically spawning above the proposed damsites are presented in Table 3.

Recommended downstream releases listed in Table 4 would improve areas below the dam to partially mitigate for upstream losses. These downstream flows, with construction of additional king salmon spawning area and artificial rearing facilities for silver salmon and steelhead, would maintain the anadromous fishery resources of the affected streams. Sebow and Panther Reservoirs would require relatively large artificial propagation and rearing facilities because of the numbers of fish affected and the limited stream areas remaining below the damsites. Estimated capacity and costs of these facilities are shown in Table 5.

Due to the relatively limited volumes of water having suitable temperatures for maintenance and enhancement of the fishery resources, it is possible these reservoirs may have serious water temperature problems at times, even if the reservoirs are operated solely for recreation, fish, and wildlife. This possibility will require thorough evaluation in future studies.

All of the Tenmile Creek projects except Sebow Reservoir would have serious water temperature problems if constructed at elevation 1,540 feet. Stapp Reservoir would present serious downstream fishery problems at any proposed elevation due to its shallow depth and small capacity. These possible projects would have an inadequate volume of 50-60°F water to operate the artificial propagation facilities and to maintain satisfactory conditions in the downstream nursery areas. If constructed at elevation 1580 or higher, Streeter, Cahto, or Sebow Reservoirs would probably have suitable water to maintain the fishery resources, although the water supply from Streeter or Cahto Reservoirs may be questionable in dry years. If future studies indicate that Streeter or Cahto Reservoirs would not provide suitable water to operate the artificial propagation

TABLE 2

ANADROMOUS FISH HABITAT
LYING ABOVE PROPOSED
SOUTH FORK EEL RIVER PROJECTS

Project	Potential Spawning Area 1/ (Square Feet)	Percent (Above Damsite)	Existing Nursery Area 2/ (Miles)	Percent (Above Damsite)
Tenmile Creek Total	840,000	100	43	100
Stapp	340,000	40	17	40
Streeter	480,000	57	28	65
Cahto	500,000	60	31	72
Sebow	765,000	91	39	91
East Branch Total	526,000	100	37	100
Panther	520,000	99	35	95
Redwood Creek Total	165,000	100	23	100
Frost	90,000	55	15	62
South Fork Eel River Total	Unknown	-	Unknown	-
Standley	56,000	Unknown	5	Unknown

1/ Estimated total area of potential spawning gravel based on stream survey data.

2/ Estimated miles of stream, including small tributaries, supporting juvenile salmonids based on stream survey data.

TABLE 3

ESTIMATED AVERAGE
POPULATIONS OF SALMON AND STEELHEAD
SPAWNING ABOVE PROPOSED
SOUTH FORK EEL RIVER PROJECTS

Project	King Salmon	Silver Salmon	Steelhead
Tenmile Creek	800	1200	1800
Stapp Reservoir	400	600	1000
Streeter Reservoir	500	800	1300
Cahto Reservoir	600	900	1400
Sebow Reservoir	800	1100	1700
East Branch South Fork	900	1300	2100
Panther Reservoir	900	1300	2100
Redwood Creek	300	450	700
Frost Reservoir	200	200	500
Upper South Fork Eel River 1/	7800	9500	14,000
Standley Reservoir	100	100	200

1/ Average Benbow Dam counts, 1938-1965

TABLE 4

RECOMMENDED FISHERY MAINTENANCE RELEASES
BELOW PROPOSED
SOUTH FORK EEL RIVER PROJECTS 1/

Project	Nov 1-Feb 28	Mar 1-June 30	July 1-Oct 31	Annual Acre-Feet
Stapp Reservoir	100 cfs	50 cfs	5 cfs	37,400
Streeter, Cahto or Sebow Reservoir	100 cfs	50 cfs	10 cfs	38,700
Panther Reservoir	150 cfs	75 cfs	15 cfs	58,000
Frost Reservoir	80 cfs	40 cfs	10 cfs	31,400
Standley Reservoir	15 cfs	10 cfs	2.5 cfs	6,700

1/ Additional spawning area, and artificial propagation and rearing facilities would also be required to maintain the fishery resources affected by these projects.

TABLE 5

ESTIMATED CAPACITY AND COST
OF ARTIFICIAL PROPAGATION FACILITIES

Project	Spawning Channel (Sq. Ft.) 1/	Hatchery Capacity (Yearlings) 2/	Capital Cost 3/	Annual O & M 4/
Stapp	None	109,000	$218,000	$27,000
Streeter	8,500	64,000	188,000	22,000
Cahto	12,000	75,000	235,000	27,000
Sebow	35,000	105,000	455,000	50,000
Standley	None	None	None	None
Panther	54,000	170,000	720,000	80,000
Frost	7,000	20,000	100,000	10,000

1/ Additional king salmon spawning area required with flows indicated in Table 4.

2/ Artificial propagation and rearing facilities for silver salmon and steelhead required with flows indicated in Table 4.

3/ Capital cost estimated at roughly $7.00 per square foot of spawning channel and $20.00 per pound of production for hatchery facilities.

4/ Operation and maintenance costs estimated at 10 percent of capital cost for spawning channel, and $2.50 per pound of production for hatchery facilities.

facilities and successfully maintain the downstream fisheries, then Sebow Reservoir would be the most favorable development.

Panther Reservoir (600 feet), and Frost Reservoir (700 feet) would probably have adequate volumes of cool water even when drawn down as much as 20 feet in the late summer. At the 500 foot elevation, Panther Reservoir would lack adequate depth to maintain suitable water temperatures in its lower strata. Therefore, it is doubtful that the fishery resources of the East Branch could be maintained with a reservoir constructed at this elevation.

Any of the proposed projects would inundate several miles of stream and eliminate some stream fishing opportunity. Existing angler-use of the project areas is based on juvenile salmonids and is restricted largely to the months of June and July, when these fish are most available. Present angler-use is very light, and for the pruposes of this analysis, will be considered negligible.

Tenmile Creek flows through private property and is not open to the public; therefore, it was assumed that the area below the proposed projects would be closed to all fishing as a salmon and steelhead nursery area. However, the stream section below Standley Reservoir, although generally posted against trespass, is accessible to anglers and was assumed to be open to fishing, as was lower Redwood Creek below Frost Reservoir, and the East Branch below Panther Reservoir.

Relatively large summer flows below these projects would attract large numbers of trout anglers because virtually all other streams in the project areas become very low or intermittent during the summer months. The majority of juvenile silver salmon and steelhead are small and are not particularly satisfying to catch, so it is likely pressures will be generated to supplement natural production with plants of catchable-sized trout. This will create problems both from the standpoint of supplying catchable trout and the added fishing pressure on juvenile salmon and steelhead required to maintain the adult runs.

POTENTIAL WILDLIFE LOSSES AND SUGGESTED MITIGATION

The potential reservoir sites were surveyed to determine possible wildlife losses. Inundation of the better lands along the streams would eliminate these areas for wildlife. Estimates of existing deer use are presented in Table 6. The deer in this area are nonmigratory. No special range problems were discerned, except for the possible loss of better quality forage produced on alluvial soils near the stream bottoms. A review of deer herd management data and field contacts indicate that deer herd numbers are low at this time.

Preservation of wildlife or mitigation for wildlife losses will be largely governed by the soil and habitat types in the area. Recreation development site limitations may conflict with wildlife mitigation proposals. No attempt is made in this report to specify locations or methods for mitigation. This problem will require further study at the next level of investigation. At this time it appears that mitigation in the Laytonville area could be tied to nearby public lands by improving access, consolidating land holdings, and developing some wildlife habitat. The acquisition and development costs in Table 6 are presented to provide a basis for estimating wildlife mitigation costs. These figures may be modified with completion of a specific mitigation plan. Most wildlife species are expected to benefit from the mitigation proposals.

TABLE 6

ESTIMATED DEER USE AND MITIGATION COSTS
SOUTH FORK EEL RIVER PROJECTS

Reservoir	Elevation (feet,MSL)	Deer-Days Use	Land Required (Acres)	Acquisition Cost 1/	Development Cost 2/	Annual O & M 3/
Tenmile Creek Projects						
Stapp	1540	7,600	270	$ 27,000	$11,000	$1,100
	1580	14,200	500	50,000	20,000	2,000
Streeter	1540	19,700	670	67,000	27,000	2,700
	1580	31,700	1080	108,000	44,000	4,400
Cahto	1540	25,200	780	78,000	32,000	3,200
	1580	40,500	1260	126,000	51,000	5,100
Sebow	1540	46,300	1210	121,000	49,000	4,900
	1580	80,000	1850	185,000	74,000	7,400
Standley	1880	11,000	230	23,000	9,000	900
Panther	500	9,900	270	27,000	11,000	1,100
	600	24,000	660	66,000	26,000	2,600
Frost	700	19,700	650	65,000	26,000	2,600

1/ Land acquired for wildlife mitigation would probably be relatively large parcels to fill in and guarantee access to public lands. Acquisition cost was estimated to average about $100 per acre.

2/ Development cost was estimated at $40 per acre.

3/ Annual operation and maintenance costs were estimated at 10 percent of development cost.

POTENTIAL FISHERY ENHANCEMENT

With the proposed development of most major drainages in the Eel River Basin, maintenance of the fish and wildlife resources will be difficult. The loss of many miles of stream fishing area will be particularly serious because of increasing demand for this type of recreation, and its irreplaceable nature. Therefore, as suggested in the California Water Plan, water project development of the South Fork should be directed at enhancement of the salmon and steelhead fisheries, and general recreation in preference to other possible project purposes.

Development of a watershed management program, including flood plain zoning, for the South Fork Eel River Basin is an essential part of increasing the fish, wildlife, and recreation potential of the drainage. Such a program would allow preservation of the natural beauty of the area, while reducing flood damage to private property, and avoiding the need for large flood control projects which would reduce fish and wildlife habitat.

There is already considerable public ownership along the South Fork in park lands and highway frontage. In addition, many miles of stream are open to the public even though the riparian lands are private. However, it may be necessary to provide additional permanent legal access and facilities to accommodate increased angling use attributable to the proposed projects. This possibility could be part of a flood plain zoning program and should receive additional study.

The potential for fish and wildlife enhancement associated with the proposed South Fork Eel River developments is discussed in the following sections. While the proposed projects would remove areas lying upstream from the damsites from anadromous fish production, they may have potential for enhancing downstream fisheries by increasing flows at critical times during the year. For example, downstream releases during the summer months could be increased several times over the historical flows and thus provide improved nursery area for several miles below the dams if water temperatures are suitable. Attraction, migration, and spawning flows could also be increased and stabilized during the fall months. In addition, the reservoirs would support fisheries for resident trout and warmwater species.

Reservoir Fisheries

Construction of any of the proposed projects would create new reservoir fisheries. Studies of similar existing north coastal reservoirs (Mendocino and Pillsbury) indicate that water temperatures are borderline for trout during the late summer months. These reservoirs are not particularly productive for warmwater species. Since fish grow fastest near the top of their temperature tolerance range, reservoirs that can be managed with either trout or warmwater fish are probably better suited for trout.

A Tenmile Creek project would support trout although there are already warmwater species in the drainage, which would inhabit the reservoir. Standley Reservoir would also be predominately a trout fishery, with a temperature regime similar to Lake Pillsbury. Warmwater species would likely dominate Panther and Frost Reservoirs, although water temperatures would not be optimum for either warmwater or coldwater species. Large populations of warmwater species in the South Fork Eel River basin would not be desirable, because they would supply a constant source of predatory fish to the lower drainage. Effects of this predation and competition for food and habitat with juvenile salmonids cannot be evaluated, but should be recognized.

Reservoir fishery yields for the proposed South Fork projects were estimated using Lake Pillsbury and Lake Mendocino as examples. The upper South Fork and its tributaries are slightly lower in basic nutrients than the basins of the existing reservoirs, but the proposed reservoirs should support similar productivity levels due to lower turbidity and more stable water surfaces. Panther Reservoir would be an exception to this general statement. The East Branch is consistently more turbid than the other streams proposed for development and Panther Reservoir would be correspondingly less productive than the other proposed projects.

Estimated maximum annual yields of game fish and potential angler-use for the proposed projects are shown in Table 7. Recreation studies indicate that angling demand may approach or exceed these levels in the first decades. However, the reservoirs would not maintain satisfactory angling at higher levels of use than those indicated in Table 7, without intensive management of some kind, e.g. stocking catchable-sized fish. Funds for such intensive management should come from some source other than the Fish and Game Preservation Fund.

TABLE 7

ESTIMATED POTENTIAL YIELD AND ANGLER-USE
FOR PROPOSED
SOUTH FORK EEL RIVER PROJECTS

Project	Elevation MSL	Surface Area (acres)	Total Yield of Game Fish (pounds/year) Cold-water	Warm-water	Potential Angler-Use (angler-days per year) 1/
Stapp	1580	705	15,000	5,000	35,000
	1540	375	13,000	4,000	30,000
Streeter	1580	1515	17,000	6,000	40,000
	1540	940	16,000	6,000	38,000
Cahto	1580	1760	20,000	6,000	46,000
	1540	1097	18,000	6,000	42,000
Sebow	1580	2590	23,000	8,000	54,000
	1540	1690	20,000	7,000	47,000
Standley	1880	320	8,500	1,000	18,000
Panther	600	920	2,000	3,500	7,500
	500	380	1,000	2,000	4,000
Frost	700	910	8,000	15,000	31,000

1/ Based on 0.5 pounds coldwater fish and 1.0 pounds warmwater fish required to support each angler-day.

Downstream Nursery Enhancement

The artificial propagation facilities and downstream releases described previously would maintain the existing fishery resources of the affected drainages. However, larger summer releases of cool water from the proposed reservoirs could create additional nursery habitat for juvenile steelhead and silver salmon. The abundance of these species is not usually restricted by spawning area, but by the quantity and quality of the nursery area. Therefore, additional nursery area would result in increased numbers of downstream migrants, additional adult fish in the sport and commercial fisheries, and a larger spawning run. A brief description of the downstream enhancement potential of the proposed reservoirs follows. Table 8 indicates the enhancement possible with various summer flows from each project.

Due to its small size and capacity, Stapp Reservoir would have an inadequate volume of cool water to provide downstream nursery enhancement at any elevation. In fact, as discussed previously, it is doubtful if the existing fishery resources could be maintained with this project. At the 1580 foot elevation Streeter or Cahto Reservoirs may have sufficient cold water to provide downstream releases up to 20 cfs during the summer months, except during exceptionally dry years. At lower elevations, there would be no enhancement potential. Sebow Reservoir, constructed at either elevation 1580 or 1540, would have a relatively large volume of cold water and could provide flows in excess of 20 cfs throughout the critical summer months.

Because of its location, the downstream nursery enhancement potential of Panther Reservoir is limited. Only about 1-1/2 miles of the East Branch lie below Panther Damsite. It is doubtful that flows of any reasonable magnitude would have a significant effect on the temperature regime of the South Fork Eel River below Benbow Dam.

Lower Redwood Creek could be significantly improved as a salmon and steelhead nursery area with flows of 15 or 20 cfs from Frost Reservoir providing water temperatures are suitable.

Fishery studies of the Standley project were limited and did not include determination of optimum spawning flows below the damsite. However, stream surveys of the reservoir basin and the South Fork Eel River immediately

TABLE 8

POTENTIAL DOWNSTREAM FISHERY ENHANCEMENT WITH SPECIFIED SUMMER RELEASES
SOUTH FORK EEL RIVER PROJECTS

Project	Summer Flow Release (cfs)	Potential Increased Trout Catch	Potential Increased Commercial Catch Silver Salmon	Potential Increased Ocean Sport Catch Silver Salmon	Potential Increased River Sport Catch Silver Salmon	Potential Increased River Sport Catch Steel-head
Stapp		---------- NO ENHANCEMENT POTENTIAL ----------				
Streeter	15	0	535	95	40	155
	20	0	1080	190	80	310
Cahto	15	0	480	85	35	135
	20	0	960	170	70	270
Sebow	15	0	390	70	30	115
	20	0	1040	180	80	300
Standley	5	4500	430	75	30	75
	7.5	6750	865	150	65	150
	10	9000	1295	225	95	230
Panther	20	2250	110	20	10	20
	25	6750	975	170	75	170
	30	9000	1400	245	105	250
	35	13,250	2230	390	165	400
	40	17,500	3060	535	230	540
Frost	15	5100	290	50	20	50
	20	6600	575	100	45	100

1/ These estimates are based on the assumption that the reservoirs can provide the flows indicated at a temperature of 55° F or less July 1 through October 31. Such flows would increase the carrying capacity of areas below the dams and result in increased numbers of downstream migrant salmon and steelhead and thus larger numbers of returning adults.

below the proposed damsite indicated that there is roughly as much potential spawning area in the first two miles below the damsite as would be blocked and inundated by the reservoir. The surveys clearly showed that spawning area is abundant in the upper South Fork and its tributaries, and the factor limiting fish production appears to be low summer flows.

The upper South Fork below Standley Damsite is a narrow stream, fairly well shaded by riparian vegetation. It is fed by several live streams which add cool water even during the summer months. Due to these conditions, a summer release of 5-10 cfs (55°F) from Standley Dam could provide suitable habitat conditions for juvenile salmon and steelhead downstream to the mouth of Jack of Hearts Creek, a distance of about 12 miles. The carrying capacity of this section of stream would be increased several-fold, resulting in significant downstream fishery benefits. Unfortunately, recent geological studies have indicated that 1880 feet may be the highest elevation a dam could be constructed at the Standley site. This would result in a small reservoir with only limited potential for downstream enhancement.

Early Entry

As described in Bulletin No. 92, the benefits that could be obtained by providing adequate flows to allow early entry of king salmon into the South Fork Eel River are not clear. Although king salmon are usually unable to migrate upstream from the estuary prior to the first major rainfall, this delay may not seriously affect their spawning efficiency, except in extreme situations. Based on present knowledge, it appears that increased downstream releases in excess of 100 cfs, which would ensure flows of 150 cfs or more at the Miranda gage, coupled with lower water temperatures that normally occur by mid-October, would allow king salmon to migrate into the South Fork Eel River.

The major economic benefit provided by firm early flows would result from a substantial increase in the river sport fishery for salmon and steelhead. Under present conditions, this fishery is concentrated in the lower main Eel River below the mouth of the Van Duzen River until the first major rains increase flows adequately to allow upstream migration. This usually occurs about mid-November. The frequency and intensity of storms during late November and December often keeps the river too turbid

for successful angling except for brief periods. Usually, there are only about ten days to two weeks each year when salmon are in the South Fork and the river is fishable. Thus, early flows which would allow salmon and steelhead to migrate upstream and distribute themselves throughout the South Fork could easily double the number of days when the river is fishable and thereby increase potential angling-use for salmon and steelhead.

This would mean anglers in distant metropolitan areas could travel to the South Fork Eel River with reasonable assurance of finding good fishing conditions. Under present conditions it is very uncertain from day-to-day if the river will be fishable, once fish are in the river. A reliable and improved fall sport fishery would lengthen the recreation season in the area, resulting in obvious economic benefits to the local recreation service industry.

The California Fish and Wildlife Plan indicates that salmon and steelhead fishermen now expend about 18,000 angler-days annually on the South Fork Eel River. With suitable early fall flows, it is reasonable to expect that this use could double or triple within a few years.

Increased summer and early fall flows from the projects might also induce "half-pounder" steelhead to enter the South Fork earlier in the fall, thus lengthening the angling season for these fish. However, the effect of increased use on this fishery is unknown.

Increased Spawning Area

Regulated flow releases from the proposed projects during the spawning season would provide additional spawning area for king salmon, especially during dry years. Sustained flows could increase numbers of king salmon by resulting in a better distribution of spawning salmon throughout the drainage, and reducing the number of eggs stranded when flows drop between storms. During very dry years when there is insufficient rainfall before late December or early January to allow king salmon to reach desirable spawning areas in the upper drainage, many salmon spawn in lower reaches of the river where the incubating eggs are more vulnerable to scouring from later floods. Early flows would greatly improve spawning conditions in these years.

An analysis of mean daily flows in the South Fork Eel River near Miranda for the months of October, November, and December, indicates that

firm spawning flows of about 500 cfs at Miranda would provide approximately 40 percent more spawning area than existing natural flows. Assuming that the king salmon population will expand to utilize the additional spawning area, the existing runs of king salmon may be expected to increase by roughly 40 percent. Studies leading to Appendix C, Bulletin No. 136, indicated an historical average spawning run of approximately 10,000 king salmon in the South Fork Eel River below Tenmile Creek, excluding tributaries. Therefore, the maximum potential increase in the spawning run is estimated at 4,000 king salmon. Table 9 indicates the enhancement potential at various spawning flows.

TABLE 9

POTENTIAL DOWNSTREAM FISHERY ENHANCEMENT
FROM PROVIDING FIRM SPAWNING FLOWS FOR KING SALMON

Downstream Release From Proposed Projects (Oct. 1 - Dec. 31)	Minimum Combined Streamflow at Miranda Gage	Potential King Salmon Enhancement			
		Increased Spawning Run	Increased Commercial Catch	Increased Ocean Sport Catch	Increased River Sport Catch
Cahto - 100 cfs	150 cfs	1600	2560	450	190
Cahto - 150 cfs	200 cfs	2100	3360	590	250
Cahto - 100 cfs Panther - 150 cfs	300 cfs	3100	4960	870	370
Cahto - 150 cfs Panther - 200 cfs	400 cfs	3600	5760	1010	430
Cahto - 200 cfs Panther - 250 cfs	500 cfs	4000	6400	1120	480

POTENTIAL WILDLIFE ENHANCEMENT

No significant wildlife enhancement is anticipated. Reservoirs with stable water levels would replace some of the existing wildlife habitat with a different kind attractive to species of wildlife associated with lakes. Development of a mitigation program may provide some incidental enhancement.

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